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THE SOCIAL SCIENCES AS A FACTOR IN INTERNATIONAL COLLABORATION

IT is a feature of the reviews of the year's work of the Rockefeller Foundation which its president, Mr. Raymond B. Fosdick, is accustomed to give, that they provide not merely a picture of the activities of the Foundation but also of the fundamental needs and problems in the intellectual as well as the physical life of mankind that the Foundation is trying to serve or to solve. In this way these reviews have come to possess a value for assessing the importance or significance of trends in the scientific world or in the activities of other organisations that is almost unique. The review for 1946 admirably illustrates this characteristic, and will be read with interest and profit by those interested in the new World Health Organisation established under the United Nations, the development of the social sciences, the fostering of understanding between the West and the East, or the promotion of that full intercourse of minds in every field of intellectual effort upon which the advancement of knowledge depends.

The Foundation has made concrete contributions in all these fields during the year. Grants to the social sciences totalled 2,633,677 dollars, covering four primary fields. Those in the first field, of international relations, went to bodies conducting research and education designed to strengthen the foundations for a more enlightened public opinion and more consistent public policies; they included one to the Food Research Institute, Stanford University, for the preparation of a history and appraisal of the world's experience in handling food and agriculture during the War, and two grants dealing with the question of the social implications of atomic power. In the second field, of economic research, grants were made to the Economics Research Section, University of Manchester, the Department of Applied Economics, University of Cambridge, and the Institute of Economics, University of Oslo. In the third field, four or five modest grants were made in support of studies in the functioning of American political democracy; while in the fourth field, of research and training agencies, 216,000 dollars were voted to the Social Science Research Council, the Canadian Social Science Research Council and Johns Hopkins University. A final grant of 250,000 dollars was made for the erection of the giant 200-inch telescope on Mount Palomar in California, making a total appropriation of 6,250,000 dollars to the California Institute of Technology for this purpose.

Announcement of these grants, however, is not the most impressive feature of Dr. Fosdick's review. It is when he goes on to ask what is the justification for this huge expenditure of money and effort, and to discuss the implications of the unconquerable exploring urge within the mind of man, that Dr. Fosdick touches on the fundamental issues. He does not deny that knowledge is dangerous, but he insists that the answer does not lie in trying to curb science or to fix boundaries beyond which intellectual adventure

should not be allowed to go. The search for truth, he maintains, is, as it always has been, the noblest expression of the human spirit. Man's hunger for knowledge about himself, his environment and the forces by which he is surrounded, gives human life its meaning and purpose, and clothes it with final dignity. Civilization is not being betrayed by science: the danger lies in the failure to use science wisely.

This is the point of view which has prompted the Foundation to extend the support of the social sciences already noted. The lack of balance in research is admitted. Our knowledge of human behaviour and social relations is inadequate to give us the guidance we need through the rapid changes in our physical environment. The fundamental issue of our time is whether we can develop understanding and wisdom reliable enough to serve as a chart in working out the problems of human relations, or whether our lopsided progress will be allowed to develop to a point that capsizes our civilization in a catastrophe of immeasurable proportions.

What is needed, Dr. Fosdick continues, is a broader basis of research, a more vigorous backing of objective and competent efforts to define and analyse the intricacies of human relationships. We need to know what our social organisation is, how it operates, and how it will react to alterations and changes. In our interdependent society, issues are no longer simple, individual and local; they are complex, social and world-wide. Our real need is a mastery not of Nature but of man's social nature, and of the social consequences of physical and mechanical advances which are shaping our lives to undesired ends.

An encouraging feature in the situation is the increasing recognition of the importance of the social services, even although it has yet to secure the necessary expansion of effort in this field. Like the Clapham Report, Dr. Fosdick insists on the importance here of disciplined minds and the high integrity of objective scholarship. We must secure a continuous flow of first-class talent into these fields, for the standard of research will depend on the quality of the men just as much as it does in the physical sciences.

But while the Rockefeller Foundation concerns itself both with the endowment of research in specific fields and with the training of men, it is equally concerned with the conditions which make research fruitful, and the appropriations of the Foundation have been distributed internationally with the purpose of breaking down the isolation and intellectual stagnation which war brings. The flow of ideas across boundary lines, the free exchange of periodicals and books, and the cross-fertilization of minds working in the same scientific and cultural fields—the interruption of these are among the tragic losses of war the magnitude of which Dr. Fosdick rightly points out is impossible to assess. We shall never know the advances which might have occurred had there been contact during these years between the biologists, the biochemists, the physiologists and mathematicians of the United States and a dozen Western European countries, or if, for example, the energy and knowledge and unselfish co-operation which were devoted to making the atomic bomb had been applied instead to some of the great basic problems of biology and medicine.

It is implicit in Dr. Fosdick's review that war interrupts and hinders the advance of science; but the review shows unmistakably the determined effort the Foundation has made to assist the resumption of research and to link up the intellectual life of Europe with that of the rest of the world. Europe is still perhaps the world's greatest power-house in terms of brains and skill, of human values and creative talent, and the grants made by the Foundation in its chief divisions—natural sciences, medical sciences, humanities, social sciences—have been designed to provide equipment and support for universities, libraries and research centres as well as to create methods of communication by which such institutions can re-establish contacts with each other and with the rest of the world, as, for example, through a series of international conferences in such fields as chemical genetics, protein structure, enzyme chemistry and cellular physiology. Into this international stream it is important to bring Russian scientific thought, and a grant has been made for that specific purpose.

Dr. Fosdick does not claim that the Foundation has been able to do more than make a very modest contribution towards the initiation of efforts to solve the great problems which Europe's intellectual needs present, and he looks very plainly to the United Nations Educational, Scientific and Cultural Organisation for the major contribution in this field. If, as Prof. L. A. Du Bridge urged in an address to the Society of the Sigma Xi and since published in *The American Scientist*, the fundamental problem is to turn the great resources of science into the paths of peace, that problem can never be solved by one country alone. Prof. Du Bridge puts the freedom of science first in his programme, and insists that no measures for extending the training of scientific workers, educating the public as to what science could contribute to the welfare of mankind, and expanding and improving the resources for research in pure and applied science, must impair that freedom; and he recognizes that fundamentally the problem of science is not national but international. Science must be applied to the specific problems of human adjustment, and the conduct of affairs be guided by the scientific method of critical examination and evaluation of actual experience rather than by raw emotion, vested authority, or prejudice, not just in one nation, but in the relations of nations with one another.

No durable world order can be established until we approach this condition, and the real hope of the Educational, Scientific and Cultural Organisation of the United Nations lies in the contribution which its work can make to that end. Therein, perhaps, is the importance of the project for the creation of the International Institute of the Hylean Amazon, now to be examined by an international scientific commission. The field work of the three scientific investigators who are going to Brazil for this purpose will constitute the first international co-operative scientific effort in a gigantic forest area, the natural resources of which, from the scientific point of view, are virtually unexplored. The proposed Institute will study the

botanical, zoological, chemical, geological, meteorological, anthropological and medical facets of this area and also its potentialities as a habitat of non-indigenous peoples.

It is no disparagement of the three major projects already approved by the Executive Board of the United Nations Educational, Scientific and Cultural Organisation for 1947—an educational reconstruction programme on behalf of devastated member countries; a campaign for the spread of fundamental education; and the promotion of international understanding, primarily in education—to suggest that such projects as this for the Amazon basin are of outstanding importance. The demonstration in such ways of the practical contribution of science to human welfare is one of the most valuable factors in the task of educating public opinion in all countries as to the place and value of the scientific approach. It may be that the way towards world order is through the slow growth of a series of social experiments on the lines of the Tennessee Valley Authority, with its demonstration of the possibilities and effectiveness of co-operation between the expert and the ordinary citizen. But while such experiments lie outside the field of the United Nations Educational, Scientific and Cultural Organisation, that Organisation can still do much to prepare the way and to promote the conditions of success. Nor should it be forgotten that the pursuit of science for its cultural value remains worthy of man's best effort.

Science, indeed, has a contribution to make to the cultural and moral equipment of mankind as important as that of any body of literature or art. Indeed, from the point of view of world order, the contribution of science is unique. 'Alone of man's major intellectual interests, science has no frontiers and no national varieties; like peace, science is one and indivisible. Dr. Fosdick's review in the annual report of the Rockefeller Foundation demonstrates admirably how science can help, unobtrusively but persistently, in the task, not merely of repairing the havoc of war and ameliorating man's material life, but also of promoting a wider understanding of human affairs, human values and motives. Upon these factors may some day be firmly based a true science of social living and a world order in which man's cultural and spiritual needs no less than his material wants find ample satisfaction.

KINETICS OF BACTERIAL GROWTH

The Chemical Kinetics of the Bacterial Cell

By Prof. C. N. Hinshelwood. Pp. x + 284. (Oxford: Clarendon Press; London: Oxford University Press, 1946.) 20s. net.

THIS book is not a treatise or a monograph. It is an essay, in which the author has expanded the main ideas which led to his own and his group's important work on the kinetics of bacterial growth. Actually this essay has one major theme on which attention is constantly focused: the cause and mechanism of 'adaptive' variation of enzymatic properties in the bacterial cell. Indeed, the importance of the problem could scarcely be overstated, since a clear understanding of these phenomena, as they occur in bacterial cells, might throw light on basic problems in other fields of biology, such as genetics and embryology.

A large body of interesting experimental results, mostly from the author's own laboratory, has been condensed in the book, the greater part of which is concerned with the acquirement and loss of the capacity to resist drug action, or with using new sources of carbon and nitrogen. This will no doubt prove very useful for future reference.

The main object of the theoretical discussions is to see whether, and to what extent, these experimental data may be interpreted in terms of rather simple models of linked enzymatic reactions, that is, whether various types of change of properties may be considered as resulting from an 'automatic response' to a new environment. Practically all the discussions and mathematical treatment of the data are based upon one fundamental assumption, which is that each individual metabolic reaction may be represented by an equation of the type:

enzyme + substrate = more enzyme + products.

Now, the exact meaning of this equation is not altogether clear, at least at first sight, and to realize all the implications of such an assumption requires, and merits, a good deal of thought. Assuming that all the enzymes of a cell are autosynthetic structures seems to be a very bold step indeed. The fact that bacteria do grow, generally, when supplied with the necessary foodstuffs does not seem to be quite enough to justify it. It might be regretted that such an essential point should not be discussed at length, and that no *direct* experimental evidence in favour of it should be presented. (Although, in the reviewer's belief, some such evidence seems to exist, at least in a limited number of cases[1].)

However, once this postulate is accepted, interesting conclusions follow, and it is shown that the behaviour of bacterial populations submitted to new or adverse conditions can be understood as resulting from automatic adjustments of the 'enzyme balance' within each cell. The experimental data leave little doubt that this view must be essentially correct in many cases. In others, however, the evidence is far less convincing. For example, it is shown, on theoretical grounds, that prolonged 'adaptation' may conceivably lead to an *irreversible* stabilization of the new condition. This is a highly important point, as it raises the question whether such changes would be reflected in the bacterial 'genome' the existence of which seems more and more certain. Experimental proof of this point, unfortunately, appears rather doubtful, since the results might be explained just as well (sometimes much better) through the action of selection on spontaneously arising mutants.

True, the occurrence of spontaneous mutations and the importance of selection as factors of bacterial variability are discussed at some length, the general conclusion being that it seems more 'profitable' and less 'arbitrary' to consider most changes as resulting primarily from adaptive reactions, rather than from spontaneous mutations. This type of discussion is not very convincing, however. It might be argued that the 'autosynthetic enzyme' hypothesis also appears somewhat arbitrary, and that the mutation hypothesis has actually proved highly profitable in a number of important recent contributions (such as Lwoff and Audureau's work on *Morazella*[2], Luria and Delbruck's[3], and Demerec and Fano's[4] papers

on spontaneous mutations to phage resistance, Demerec's[5] work on penicillin-resistant mutants), which are not discussed.

An important chapter deals with the subject of cell division. Interesting data and interpretations are presented there, which tend to emphasize the relative independence of 'growth mechanisms' and 'division mechanism'. It is shown that, in some cases at least, each may be subject to very specific influences. This distinction undoubtedly is of great theoretical and practical importance, although it is too often overlooked.

The book ends with 'concluding observations' of a far-reaching generality, on the essential characteristics of living matter, and the possibility of understanding its origin and evolution in terms of physical forces and relations. The view is optimistic, although prudent, and it is pointed out that even the dualism of the mental and physical world may in time appear as a functional relation, the nature of which would not be very much more difficult to grasp than the relation between wave and particle, energy and matter.

J. MONOD

[1] cf. Spiegelman, *Ann. Missouri Bot. Garden*, **32**, 139 (1945).
[2] *Ann. Inst. Pasteur*, **67**, 94 (1942).
[3] *Genetics*, **28**, 491 (1943).
[4] *Genetics*, **30**, 119 (1945).
[5] *Proc. U.S. Nat. Acad. Sci.*, **31**, 16 (1945).

BRITISH FOREST TREES

Our Forests

By W. H. Rowe. Pp. 173+34 plates. (London: Faber and Faber, Ltd., 1947.) 12*s.* 6*d.* net.

THIS is the second book covering the general subject of British forestry for the non-technical reader published since the end of the War ("Forests and Forestry", by W. L. Taylor, the recently appointed director-general of forestry, being the other), and during the same period, Edlin's book on "British Woodland Trees" has also appeared. This is a very healthy sign of an increasing interest in the woodlands of Great Britain and their place in both rural and national economy. All three books are well illustrated, and Mr. Rowe has made an excellent choice of subjects. The frontispiece, taken in a New Forest roadside plantation well known to foresters, provides an ample refutation of the charge that a coniferous crop need be an eyesore, while Figs. 5 and 6 of neglected larch woods show how one may become so; the dark thicket stage shown in Figs. 21 and 22 is after all a relatively short one. It may be claimed that the bad beech of Fig. 7 has a certain attractiveness of its own, but does it surpass that of the good beech of Fig. 8 alongside? Several of the photographs reveal what excellent growth is obtainable in Britain with a number of kinds of timber tree.

The author, already known from the useful Penguin on "Trees and Shrubs", sees forestry from the private owner's point of view, but evenly distributes the blame for the past neglect of so many of our three million acres of private woodland between both the owners and the State; he would seem to favour State control over them, but by an authority separate from the Forestry Commission responsible for the State forests—an arrangement found in some Continental countries.

There are various general statements scattered through the book that need amplification or qualification. Thus we are told that ploughing complicates rather than aids planting without giving any material advantage to the trees (p. 80), that pruning increases the volume of timber (p. 94), that the pine beetle breeds in the tops of old trees (p. 104), that the alder gives the best charcoal (p. 158)—this is only true if one wants charcoal for fuses—and that European larch and Japanese larch can be mixed with satisfactory results. There is an injunction we should not care to have to carry out in dealing with honey fungus attacks, namely, digging up all the rhizomorphs, and we cannot endorse the statement that beech does not coppice well and is on the other hand very suitable for natural regeneration in Britain. There is, too, the surprising inclusion of lime among the list of materials derived from wood (p. 158). We admit to having to refer to a dictionary to find out the meaning of the word "myrobellan" hedging (p. 82), and "coda" (p. 168).

Two chapters are devoted to notes on the individual kinds of trees. It is always difficult to know what to include and what to omit in such notes; but those given in these chapters, supplemented by those for timber uses given on p. 159, will be found useful by the people for whom the book is intended, though they are sometimes incomplete to the extent even of being misleading. One might perhaps have expected to find lodgepole pine mentioned, as it is to be seen at high elevations in many plantations in Britain, and a somewhat fuller account of sitka spruce in view of its now extensive use and the remarkable rates of growth recorded under favourable conditions. The difficulty of raising silver fir as a crop should have been mentioned.

It may be said in conclusion that it is an easy book to read and should certainly fulfil the author's avowed aim of being useful and interesting to the non-expert and general reader.

H. G. CHAMPION

ADVANCED ORGANIC CHEMISTRY

A Text-Book of Organic Chemistry

By Dr. Julius Schmidt and Dr. H. Gordon Rule. Revised and edited by Dr. Neil Campbell. Fifth edition, revised and extended. Pp. xi+939. (London and Edinburgh: Gurney and Jackson, 1947.) 32*s.* net.

THE appearance of a revised edition of this well-known work only four years after the last one calls for no comment in view of the momentous events of those years, both in the world of chemistry and elsewhere; it is indeed a tribute to the zeal of Dr. Campbell that he has not been content 'to allow chemical grass to grow unnoticed'. The printers and publishers are also to be congratulated on having completed a considerable task at a time of very great difficulty, in a manner that is a credit to all concerned.

One could wish, however, that British printers could emulate those in the United States in the neatness with which structural formulæ are reproduced. A glance at the varied and elongated benzene rings, some with double bonds and some without, apparently indiscriminately, and with substituents printed in the same way as hetero-atoms, when compared with the neat regular hexagons of some modern American books, is distressing; it is only fair to point out that this untidiness is found not only in this book, but also in all British publications with

which the reviewer has come into contact. The reason is doubtless that it is not easy to print regular rings except from special blocks, the expense of which would be considerable; the fact remains, however, that the American books are little, if any, more expensive, but possibly they have a larger circulation.

The general plan of the work remains as before, and it is suitable for the advanced student and research worker rather than the novice. The first hundred pages consist of a general section treating such topics as structure, isomerism, tautomerism, physical properties and nomenclature, all essential to the proper understanding of organic chemistry, but written for the most part in such a way as to be unsuitable for the beginner: a notable section describes the basic features of chromatography.

The following three parts deal about equally with aliphatic, carbocyclic and heterocyclic compounds in a systematic manner. This arrangement and its subdivisions will be well known, as there should be no one teaching or studying organic chemistry who is not familiar with the previous editions.

It is inevitable in a book of this kind that in order to cover the field in a reasonable space much of the matter should be compressed and simplified; it is perhaps a pity that in some instances such great brevity has been considered necessary, but to compensate for this, innumerable references are given which should make it very easy for any particular topic to be studied further.

The pages to which one naturally turns at present are those dealing with such substances as penicillin, paludrine, D.D.T., etc., the discovery and investigation of which have been among the few good things of the last bleak years: all such new compounds seem to be included with an adequate account of their history and properties. It is true the preparation of paludrine and the evidence for the structure of penicillin are not given, but it is probable, when the long delays in printing are considered, that neither had been published at the time the manuscript was prepared; no doubt they will be included in the next edition. Some few pages are devoted to nucleic acids.

Errors in the text are few and seem to be minor misprints; the index, of vital importance in a book of this sort, would appear to be adequate.

CARBOHYDRATE METABOLISM

Carbohydrate Metabolism

Correlation of Physiological, Biochemical and Clinical Aspects. By Prof. Samuel Soskin and Dr. Rachmiel Levine. Pp. viii+315. (Chicago: University of Chicago Press; London: Cambridge University Press, 1946.)

THIS interesting and instructive work on carbohydrate metabolism by Dr. Soskin and Dr. Levine, who have themselves contributed much of great value to the subject, is divided into five sections.

The first section deals briefly, but very clearly and adequately, with the many enzymic mechanisms involved in the chemical transformations which take place when carbohydrates break down in the living cell. The section concludes with chapters on the mode of liberation and transfer of the energy derived from carbohydrate metabolism and on the manner in which this energy is utilized for muscular contraction. The main part played by adenosine triphosphate in the reactions of the cell is emphasized, and the significance of the work of Engelhardt and of Szent-Györgyi, on the importance, for muscular contraction, of the proteins myosin and actin, is pointed out.

The second section presents considerations concerning the nature and occurrence in the tissues of substances important in carbohydrate metabolism, and discusses the origin of blood sugar and the use of the diabetic organism for the experimental study of gluconeogenesis. The next section contains a critical survey of the classical criteria of diabetes, introducing the reader to the investigations of Minkowsky, and later workers, on the dextrose–nitrogen ratio, and deals with the subject of ketosis, showing how modern views of fatty acid breakdown supplant the older theories of ketogenesis and antiketogenesis. The complicated question of respiratory quotient is discussed, and this is followed by chapters on gluconeogenesis from protein and fat.

The fourth section presents the main course of the appetizing menu provided by Dr. Soskin and Dr. Levine. This portion of the book deals with the role of the endocrine glands in carbohydrate metabolism. The mechanism of action of insulin is fully discussed, and it is evident, as the authors say, "that while we are perhaps closer to the solution of insulin action than we are to the action of any other hormone, the problem is far from solved". The influence of the pancreas, the adrenal cortex, the thyroid and the anterior pituitary glands in the control of carbohydrate metabolism is described in some detail.

The final section has to do with what the authors term the integration of physiological and clinical aspects of carbohydrate breakdown. Dextrose tolerance curves in the normal and diabetic organisms are discussed and the effects of the various endocrine secretions in blood sugar regulation are outlined. This is followed by an account of the clinical disturbances, in the endocrine control of the blood sugar, that accompany disease or dysfunction of the glands or of the liver. The book ends with a note showing how present lines of investigation indicate that it is becoming impossible to subdivide the subject of metabolism into separate compartments, there being so many substances of simple chemical structure which are common to many phases of cell metabolism. The limitations and potentialities of present lines of work in advancing both endocrinology and pharmacology are pointed out.

The book is a clear and able exposition of many of the facts of, and the modern views bearing on, carbohydrate metabolism. It is a pity, perhaps, that a little more was not said on the subject of the association between certain forms of mental disturbances and carbohydrate breakdown—a subject of great interest to the psychiatrist who has witnessed the effects of insulin shock treatment in schizophrenia, or the effects of carbohydrate in improving prolonged narcosis treatment both in psychoses and neuroses. The importance, too, of glucose in securing, under physiological conditions, the synthesis of acetylcholine in the central nervous system might have been commented upon.

The work has most useful schematic representations which help to clarify the subject-matter, and more than a thousand references. It is an excellent book which should be read by all interested in recent work on the metabolism of carbohydrates in the animal body.

J. H. QUASTEL

THE MISSING FACTOR IN SCIENCE*

By Prof. HERBERT DINGLE

Professor of the History and Philosophy of Science, University College, London

IT is now more than three hundred years since Galileo originated the process in philosophy which, in its maturer form, we now call science. This "method of philosophating", to use Salusbury's quaint seventeenth-century phrase, calls for careful scrutiny—not, at this time of day, to decide whether it has value or not, but to determine precisely what its value, its significance and its potential danger might be. One aspect of science, I think, is in general imperfectly appreciated, namely, its essentially progressive character. The motive-power behind all philosophy is the need or the desire to understand the meaning of experience, and especially those parts of experience which touch us most deeply. Accordingly, the pre-scientific philosophers took all experience for their province and aimed at producing at once a scheme of things which could comprehend the whole.

The philosophy which has come to be known as science made a radically different approach to the problem. The problem itself was the same—the interpretation of all experience; but the first requirement was certainty, not completeness. There was one department of experience in which certainty could be attained—namely, our experience of the movements of bodies. We could study these and obtain results which could be checked and confirmed. True, such knowledge was not soul-shaking, but it carried conviction with it, and on it as a basis one might mount to further knowledge, until at last it might be that the whole secret of experience would be read—not now plausibly conjectured but guaranteed as certain by its attainment through verified experience itself. And so the early men of science stopped discoursing of the origin and destiny of man and began to roll balls down slopes, to swing pendulums, and to weigh the water which dripped from a bottle. They had not necessarily a different standard of ultimate relative values from the other philosophers, but they had a different conception of how the goal could be reached.

Several consequences follow from this, of which I will mention only one—namely, that the history of science is inseparable from science itself. Science is essentially a process, stretching through time, in contrast with the instantaneous or eternal character of traditional philosophy. Scientific workers may forget the ground on which their knowledge rests; but they are not then educated men. To the true man of science they are as the artificer to the artist, the sleep-walker to the explorer, the instinctive cry to the pregnant phrase. Such a one may achieve much of value, but he is also a potential danger. At the moment he happens to be a profoundly disquieting menace to our civilization.

Let us look at this question of science and civilization, for although I believe that in its profoundest sense science is a personal philosophy and that its character as a progressive discovery of the interconnectedness of our experience is a plant of which its present social function is a transient flower, there is no doubt that the relation of science to communal life is the question of the moment. The progress of three hundred years is indeed amazing, and its effect on our social life overwhelming. Materially, our civilization is shaped and directed by science. The possibilities in the control of life loom over us like thunderclouds, big with menace or mercy, we know not which. And scientific psychology celebrates its birth most noticeably by the generation of an army of third-rate novelists whose influence is all the more to be reckoned with because it is incalculable. In such a situation it is clear that there is no task more compellingly urgent for the sociologist than that of determining precisely what is this process which we call science; and when we contemplate the ideas of the essential nature of science which are most prevalent and operative to-day we find a situation fit to make the angels weep.

I do not say, of course, that one cannot find penetrating and worthy attacks on the problem in present-day writings, but one has to search for them. The ideas that command wide assent are not merely false but obviously false; they have only to be confronted with the most outstanding characteristics of science as it both apparently and actually is, to be recognized as such by the most elementary intelligence. I must limit myself to two examples.

"The cleavage between the scientific and the extra-scientific domain of experience," wrote the late Sir Arthur Eddington[1], "is, I believe, not a cleavage between the concrete and the transcendental, but between the metrical and the non-metrical." Thus arose, or perhaps was greatly intensified, the belief that the scope of science is limited to the measurable and its activities to the discussion of measurements. This was broadcast from pulpit and loud-speaker; it has found an echo in philosopher, in divine, in essayist, in novelist and in street-corner orator. No idea of the nature of science is more widely accepted to-day.

And yet, if one adopts the elementary, barn-door method of comparing the dictum with science itself, what does he find? As likely as not the most typical piece of scientific achievement that will occur to him will be the outstanding generalization of the nineteenth century, the theory of evolution, and if so, he can scarcely fail to notice that that theory has nothing whatever to do with measurement. It is concerned with qualitative changes alone, and is indubitably a scientific theory which changed the course of the world's thought without introducing or depending on a single measurement. And yet intelligent and learned men say and believe that science is concerned only with measurement!

My second example can be introduced by a passage which forms the starting-point of Prof. J. D. Bernal's recent consideration of the social function of science[2]. After contrasting two definitions of science—one, that it is "a pursuit of pure knowledge for its own sake", and the other, that it is "the means of obtaining practical mastery over nature through understanding it"—Bernal decides in favour of the second, and on it bases the whole of his subsequent argument. Now here again the consequences of adopting such a view are far-reaching and momentous. As everyone knows, political theories based on such a view of science are extremely active and powerful at the present time. Clearly it is worth while looking again at science as it actually is, to see if it conforms to this definition.

There are several ways in which we can do this. Perhaps the most direct and unquestionable is to look at the universal criterion by which papers submitted for publication to recognized scientific societies

* Substance of the inaugural lecture delivered at University College, London, on June 6.

and journals are tested, for the essence of authentic science is contained in the publications of such agencies. And if we ask whether mastery over Nature forms any part of that criterion we see immediately that it does not. Or let us look at any examination paper for a degree in science. We shall find a large variety of questions, but none concerned with mastery over Nature. Or let us ask the "New English Dictionary", which purports to give all the commonly accepted meanings of words, what the word 'science' means. It will give us thirteen answers, but obtaining mastery over Nature is not one of them. Or let us look at the achievements for which the well-recognized prizes and medals are awarded to men of science. Again we shall look in vain for examples of mastery over Nature. After which it is perhaps superfluous to recall that the most terribly obvious characteristic of science to-day is that it is a means by which Nature seems about to master us.

Now this phenomenon, of which I have given two examples, is extremely disquieting. That it has not aroused adequate alarm is, I believe, simply because it appears incredible and so its possibility is not entertained; but there is no doubt about it. Let us face it squarely and see what it means. It is not a matter of a few ignorant demagogues giving hasty generalizations which fail to cover minor details. Here are two distinguished thinkers, undoubtedly men of exceptional ability and deservedly held in high esteem in the scientific world, making statements of the greatest import which even an intelligent child can see to be directly contradicted by facts—not obscure facts but the outstanding, the obvious facts. And the statements are believed; and not only believed but made the basis of thought and action. The situation would be comic in some circumstances; but, standing as we do at a point in the world's history where nothing but a stark realization of facts in their naked simplicity can avail to save us, the mask of comedy drops from it and it appears tragical. What is to be done about it?

It is not my task, or within my competence, to propose an immediate course of action for the salvation of the human race, but it is my task to inquire how it has come about that a generation so amazingly proficient in the practice of science can be so amazingly impotent in the understanding of it, and the thesis I wish to propose is that the state of unselfconscious automatism in which science finds itself to-day is due to the lack throughout its history of a critical school, working within the scientific movement itself and performing the function, or at least one of the functions, which criticism has performed for literature from the earliest times. Greek tragedy, as well as its Euripides, its Sophocles, had its Aristotle; Roman poetry could show, with Horace and Virgil, a Quintilian, a Longinus. Throughout the ages there has gone, hand-in-hand with the work of the creators, the interpretation of the critics—Dante, Jonson, Dryden, Lessing, Wordsworth, Coleridge, Sainte-Beuve, Arnold—and the result, in spite of abuses, notwithstanding mutual recriminations and misunderstandings, has been that the stream of literature, without losing its momentum, has been directed, so that its power, which otherwise would have largely wasted itself in aimless dissipation, has been able to produce a cumulative effect.

We look in vain for the corresponding names in science. True, there occasionally arises a Mach, a Duhem, a Pearson, but they are conspicuous by their scarcity, and few heed them. The great bulk of the critics of science have not been within the scientific movement, and their aim has been in the main not so much to understand as to discredit it. The one-sidedness, the blindness, the coldness of science have been preached *ad nauseam*, and the men of science themselves, if they have looked up from their work to notice the attacks at all, have been contented with a half-hearted defence, satisfied for the most part to be obviously doing something without caring to define even to themselves what their activity means. Science has thus progressed like a ship with an all-powerful engine and no compass or rudder or steersman, measuring its progress in knots and not in terms of approximation to a desired haven, while its only 'guidance' has come from airmen overhead who, knowing nothing of its nature and potentialities, shriek their conviction that it will never reach the stratosphere.

It is not difficult to see how this lamentable difference between science and literature has arisen. Literature in its naked simplicity has no intrinsic standards, and was thus led by necessity to become self-critical. But science *has* intrinsic standards. A scientific statement must, directly or indirectly, express experience and be subject to the test of experience. If the expression is indirect, the connexion must be rational. These requirements have been satisfied by men of science with a consistency and purity of practice that is not even approximately equalled in any other large-scale human endeavour; that is why science has made such astonishing progress in so short a time. Over its terrain of rocks and quicksands science walks as sure-footed as a mule—and as sapient. It has no need of standards of judgment and so has produced no critical school, but by this omission it has lost the other and greater benefit which such a school can give—namely, that of surveying, describing and interpreting the movement itself. That is why it can combine such brilliancy of achievement with such obscurity of understanding.

A critical effort within science can perform at least two necessary functions. It can direct the movement itself, so that blind alleys are avoided and the path of progress illuminated; and, still more important for the world as a whole, it can make science self-conscious and aware of the significance of what it is doing in relation to other human activities. This cannot be done effectively from outside; it is only within the world of science that the necessary knowledge exists. It is no small calamity, therefore, that that world, with some honourable exceptions, is so indifferent to the attempt to understand and interpret its own activities. It makes no provision for recognizing and encouraging such an endeavour. Let me throw one sidelight on this, to reveal the general position. Sir Arthur Eddington spent the later years of his life in developing a theory of the fundamentals of physics which has met with little response because of the difficulty of understanding what it is all about. Nevertheless, it contains such an impressive wealth of agreement between theory and observation that it is impossible any longer to doubt that the theory contains something of the most profound significance. Both the intrinsic value of the theory and the illegitimacy of at least part of Eddington's exposition of it appear unquestionable.

Now let us imagine a thinker whose powers of penetration enable him to pierce through the obscurities of Eddington's diction to the underlying truth;

to realize also, with equal clearness, the more orthodox points of view of Einstein, Bohr, Dirac and others; to see wherein the outlooks differ and how they can be reconciled; and to re-express the work of all in terms compellingly obvious, so that the contribution of Eddington can be assessed at its true value and physicists everywhere united on a common front in an immensely strengthened position for apprehending and solving the problems that remain. There can be no doubt, I think, that such a man would render to physical science the greatest benefit possible to it at the present time; yet the world of physical science has no provision for acknowledging such a benefit. For slightly inferior intellects there are Copley Medals, Orders of Merit, Nobel Prizes and the like, but for him, nothing. Like Bunyan's Interpreter, he makes pilgrimage possible, and is heard of no more. He has added nothing to knowledge; he has not discovered a single new fact of observation or revealed a single relation between measured quantities or introduced a single new concept into the subject. Everything of that kind has been done by others before him; he has simply brought to light what they have done. I submit that a condition in which clear-sighted understanding is esteemed so lightly in comparison with blind achievement is not one which ought to be regarded without misgiving.

If we try to look into the immediate future the misgiving grows. We are about to experience a great increase of scientific activity. Existing universities are to be enlarged and new ones created, and we may look forward to a rapidly growing army of young workers, becoming more and more specialized as time goes on. Competition for entry to the Royal Society will be greatly intensified, and since entry is to be gained by doing things and not by knowing what one is doing, those who pause to reflect on the meaning of their work will fall behind in the race and remain outside. At the present time the Royal Society contains, chiefly among its older Fellows, some—though far too few—who have been able and willing to supplement their specialized work by giving attention to its wider implications. Through their labours and those of their forerunners the Society has supported research into the nature and history of science in various ways, for which we cannot be too thankful. But such efforts will almost inevitably decrease, and while I do not believe that the race of historians or philosophers of science will die out, the conditions of the time will be such that they will be automatically segregated. Instead of a vigorous critical school growing up within and promoting the welfare of science, we are likely to have an artificially stunted one growing up without and conflicting with it. Such a prospect bodes little good either for science or for the community as a whole.

What are the omens on the other and brighter side? Apart from the sporadic and incalculable influence of exceptional individuals, I know of only one. I said just now that our hypothetical interpreter of modern physics could receive no recognition of his service. I was wrong. If he cared to fulfil certain other conditions well within his scope, he could earn an M.Sc. degree of the University of London in the history and philosophy of science. That may seem something of an anti-climax, and if that aspect of it should tend to direct someone towards a rectification of the situation I would not wish to temper the feeling, but it is not the aspect I want to present now. The Department of History and Philosophy of Science at University College was founded in 1923. During the sixteen years prior to its suspension at the outbreak of war, 173 students, all graduates in science, took its courses, and 84 M.Sc., 18 Ph.D., and 2 D.Sc. degrees were awarded. In the first and second year since revival, 10 and 37 students, respectively, have been enrolled. From the first the courses were planned on admirable lines, and the foundations of a uniquely valuable Department have been laid. The staff, originally comprising one part-time teacher, has grown to four full-time and one part-time teachers, with assistance from other teachers of the University who have special knowledge of the history of their own science. The University, fully aware of the need for such a Department, has given it high priority in the forthcoming expansion. It needs now but the devoted and efficient service of its members to realize at least some of the high hopes that went to its establishment.

The fact that, by the award of higher degrees within the Faculty of Science, a great University recognizes the attainment, by those trained in the practice of science, of some understanding of what they have been practising has, I think, an importance out of all proportion to the present magnitude of the effort. However inadequate it may be, its influence is genuine. It begins to create within the scientific world an atmosphere in which true science, become self-conscious, can flourish and spurious science decay. As the community is called upon to consider how it is to adjust itself to a world in which the influence of science grows ever greater, it infuses into society a leaven of men and women who are not deceived by the momentary appearance of a movement which, after taking two thousand years to prepare itself, has been gathering momentum for the last three hundred years. The example of London may in time be followed by other universities until gradually the critical spirit becomes an integral part of science everywhere, and the mad rush along the primrose way to the everlasting bonfire is changed to an ordered movement towards a preconceived and deliberately chosen goal. Provided that the effort has not come too late, it may well prove in the end to have started the process which will convert science from a mysterious menace to a comprehended blessing. Such, at any rate, is its potentiality; it remains to make it actual.

[1] "The Nature of the Physical World", by Sir Arthur Eddington, p. 275.
[2] "The Social Function of Science", by J. D. Bernal (Routledge, 1939).

THE SPARK DISCHARGE

A DISCUSSION on "The Spark Discharge" was held at a meeting of the Physical Society in the Physics Department, Imperial College of Science and Technology, London, on April 23. The opening paper was presented by Prof. L. B. Loeb, of the Physics Department, University of California, Berkeley. Other invited speakers were Prof. J. M. Meek and Dr. T. E. Allibone.

In a survey of certain aspects of the mechanism of development of spark discharges, Prof. Loeb made particular reference to the distinctions between the Townsend theory of the spark and the streamer theory of the spark, as proposed by Loeb and Meek. The Townsend theory is now considered to apply only to the breakdown of short gaps in gases at low

gas pressures, whereas the streamer theory applies to the breakdown of gaps of the order of 1 cm. or more at about atmospheric and higher pressures.

According to the Townsend theory, the breakdown of a gap occurs when $\gamma e^{\alpha d} = 1$, where α is the number of pairs of electrons and positive ions created per centimetre in the direction of the electric field by a single electron, γ is the chance that a positive ion striking the cathode will liberate a secondary electron, and d is the gap-length. This expression enables the breakdown voltage of a gap to be determined from the known measured values of α and γ as functions of voltage gradient and gas pressure. As in individual cases the values of $e^{\alpha d}$ and γ fluctuate considerably about their mean measured values, variations in the breakdown voltage may be expected to occur. Prof. Loeb showed that the resulting relation between the applied voltage and the probability of a spark is in agreement with experimental observations of the time-lags to breakdown, and also establishes the basis for the correct evaluation of the threshold sparking voltage. Further, an expression can be deduced to relate the total observed time-lag with the formative and the statistical time-lags.

The streamer theory involves the same quantity $e^{\alpha d}$ in conjunction with a new parameter γ^1, analogous to the Townsend γ, but depending on photon production in the head of an electron avalanche, and the photon absorption in the high-field region surrounding the avalanche head. Here again an expression can be deduced for the observed time-lag of spark development in relation to the statistical and formative time-lags, and Prof. Loeb stressed the need for further experimental measurements of these quantities, particularly in order to determine the transition between the Townsend and the streamer mechanism.

The Townsend mechanism depends on the numbers of ions in the gap and is in agreement with Paschen's law, which states that the voltage required to cause breakdown of a uniform gap is a function of the product of gap-length and gas pressure. Meek's criterion for a spark, as based on the streamer mechanism, depends on the ion concentration in an individual electron avalanche, and predicts small deviations from Paschen's law. This anticipated failure of Paschen's law has been confirmed by recent measurements of the breakdown of uniform fields at high voltages, for wide ranges of gap-length and gas pressure, and Prof. Loeb showed that the experimental results accord in principle with those expected from Meek's theoretical calculations.

The streamer process develops across the gap to form an ionized path or spark channel through which the external circuit discharges. The breakdown of the gap is then complete, and the voltage between the electrodes falls to a considerably reduced value corresponding to the voltage drop along the spark channel. Prof. Meek described some of the results obtained by Mr. J. B. Higham and himself in investigations of the voltage gradients and current densities in spark channels for gaps up to 100 cm. in length in air and other gases. The various parameters are recorded either oscillographically or by photographic methods. In one of the records shown, for a spark in air carrying 100 amp., the voltage gradient at a time 1 microsec. after breakdown is 120 volts per cm., and at 50 microsec. is 25 volts per cm. These values of voltage gradient are considerably greater than those for continuous arcs carrying the same current. Measurements of the spark diameter show that the channel expands during its early stages at a speed of the order of 10^5 cm. per sec., in accordance with the results obtained by Flowers. The current density in the channel is initially of the order of 10^5 amp. per cm.^{2}, but it decreases rapidly and, for a 400-amp. spark in air, is about 2×10^4 amp. per cm.^{2} at a time of 1·3 microsec. after breakdown. Some records have been obtained for sparks in which the growth of the channel is restricted by a surrounding glass tube. Other records were described for sparks in liquids; in one oscillogram shown, for a 250-amp. spark in water, the voltage gradient measured at a time 1 microsec. after breakdown was 1,200 volts per cm.

Prof. Meek stated that in the measurements of current density the values given are determined on the assumption that the current is evenly distributed over the cross-sectional area of the spark. It is probable, however, that there are radial variations in the current density, and that the ion density and the current flow may be slightly higher near the centre of the spark than near the circumference. A further feature of spark channels is that emission of light persists for much longer times in certain parts of the channel than in others, so that the channel appears to break up into a series of discrete small regions of luminosity, in the manner similar to that of the occasionally observed phenomenon of 'bead lightning'. Prof. Meek referred to investigations of this persistence of luminosity which are now being made by Craggs and Hopwood.

The investigations by Schonland and his colleagues into the mechanism of development of lightning discharges were described by Dr. Allibone. By means of photographs obtained with a rotating film camera, Schonland has shown that the first stroke of a lightning discharge in open country is preceded by a streamer process known as a 'stepped leader stroke', which develops in a series of steps from cloud to ground at a speed of about $1·5 \times 10^7$ cm. per sec. When the leader stroke reaches ground, the main stroke travels up the pre-ionized channel which has been established between the cloud and the ground at a speed of the order of one tenth that of light. The large currents observed in lightning discharges flow during the passage of the main stroke. The second and subsequent strokes of a lightning discharge are each preceded by a 'dart leader stroke', which usually proceeds in a single flight from cloud to ground, at a speed of about 2×10^8 cm. per sec., and follows the track traced out by the first stroke. After each dart leader there is a main stroke which develops from ground to cloud.

Rotating-camera studies have also been made for long spark discharges in the laboratory by Allibone and Meek, who have shown that considerable differences exist in the mechanism of development of long spark discharges in non-uniform fields between a point and a plane according to the polarity of the discharge. In a gap between a positive point and an earthed plane, a leader stroke develops from the positive point to bridge the whole gap, and the main stroke then takes place along the path traced out by the leader stroke. For a negative point and an earthed plane, the discharge is initiated by a negative leader stroke developing from the point; but, after this leader stroke has grown for only a short distance into the gap, a positive leader stroke develops from the earthed plane and the two leader strokes proceed towards each other to meet in the mid-gap region. The breakdown is completed by the passage of the

main stroke along the track pre-ionized by the leader strokes. Considerable differences are observed in the characters of the positive and negative leader strokes. The positive leader stroke develops usually in a continuous manner, though steps occur when a high series resistance is included in the circuit, and these steps become more pronounced with decreasing gas pressure. The negative leader stroke develops in a series of sharply defined steps, and is accompanied by a considerable number of mid-gap streamers.

In all three papers it was evident that, although the various modern techniques of high-speed recording have yielded a considerable amount of experimental data concerning the development of spark discharges, there are still many aspects of the problem requiring further investigation. Also, while the mechanism of spark breakdown in uniform fields can now be explained in terms of fundamental processes, the interpretation of all observed sparking phenomena, particularly in non-uniform fields, is still by no means complete.

TATA INSTITUTE OF FUNDAMENTAL RESEARCH

IN India, where the number of institutions for research is very small, it is now keenly realized that much greater attention must be paid to research, pure as well as applied, if India is to keep pace with the progressive nations of the world. A result of this new outlook and a welcome addition to such institutions is the newly established Institute for Fundamental Research, sponsored by the trustees of the Sir Dorabji Tata Trust and the Government of Bombay, with the subsequent support of the Government of India. The object is to create a centre for fundamental research, with particular reference to atomic physics and mathematics, and also to train the young scientific workers of India in these subjects.

Tatas, the biggest industrialists of India, have a long tradition of foresight and wisdom in the employment of their resources. To-day, 85 per cent of their capital is held in public trusts for benevolent projects, chief among which is the promotion of higher education and research. They were the pioneers in founding the Indian Institute of Science at Bangalore, the Tata Memorial Hospital for cancer and the Tata Institute of Social Sciences at Bombay. The Tata Institute of Fundamental Research is the newest institution which owes its existence to their enterprise and munificence.

Since 1942, the Sir Dorabji Tata Trust has supported a Cosmic Ray Research Unit headed by Prof. H. J. Bhabha, F.R.S., at the Indian Institute of Science, Bangalore. It was felt, however, that the modern demands of fundamental research in cosmic rays and nuclear physics could only be met by means of a separate institute devoted entirely to these subjects. The Cosmic Ray Research Unit of the Indian Institute of Science was moved to Bombay in 1945, and formed the nucleus around which the new project was built. As the construction of new buildings was not possible during the War, the Institute was housed in temporary premises. It was formally opened on December 19, 1945, by Sir John Colville, Governor of Bombay.

On that occasion, when inaugurating the Institute, Sir John Colville said: "India stands in urgent need of the speedy development of her resources, both agricultural and industrial. This can only be achieved with the aid of science. For modern industry and agriculture rest, to an ever-increasing extent, upon scientific foundations, and economic progress depends on continual advances in the field of fundamental research which provides the material on which the applied scientist can work." Sir John Colville further remarked that: "Applied research, designed to meet the practical needs of industry and agriculture, and carried on in the laboratories of Government research stations or by particular firms, is necessary. It is, however, increasingly recognized that research of a fundamental character, not directed towards specific practical objectives, is of vital importance, because of its fructifying and stimulating influence on applied research, which, without it, is bound to languish. Applied research, in fact, must be kept constantly refreshed by contact with the original work of the pure scientist."

During the first year of its existence it became clear that the new Institute would have to expand rapidly, and the necessary funds for this expansion were sanctioned by the Government of India through the Council of Scientific and Industrial Research. The Institute is to-day administered by an independent council on which the Government of India, the Government of Bombay and the trustees of the Sir Dorabji Tata Trust are represented. At present the Institute has chairs of theoretical physics, experimental physics, pure mathematics and astrophysics. Provision is also made for a visiting professorship so as to enable the Institute to invite distinguished men of science from abroad to work in the Institute for a year at a time. The Institute has also several readerships, and posts for research fellows and research assistants. A number of students are given liberal stipends to enable them to work under the professors of the Institute.

Since its start, the Institute has completed an experiment for measuring the intensity of the penetrating component of cosmic rays up to an altitude of 40,000 ft. In this experiment the intensity of cosmic rays penetrating 30 cm. of lead was measured for the first time up to these altitudes. Several papers on the theory of the elementary particles and on new relativistic wave equations, on mathematical and statistics topics, have been published by members of the Institute.

The Institute will encourage to the utmost the exchange of scientific ideas. Recently a group of foreign men of science visited India as delegates to the Indian Science Congress, and the opportunity was taken to invite Prof. P. M. S. Blackett, of the University of Manchester, Prof. J. Hadamard, of the Institut de France, and Prof. S. S. Chern, of the Academia Sinica, as visiting professors to the Institute to deliver courses of lectures on their subjects.

The Council of Scientific and Industrial Research has decided that the Institute shall be the centre of all large-scale research in nuclear physics in India, and has sanctioned a scheme for the setting up, at the Institute, of a high-energy accelerator, capable of producing particles of energies up to 200 MeV. A team of ten investigators is being formed for this purpose. With the establishment of the high-energy accelerator, it is intended to lay down a long-range plan of nuclear research.

It is also likely that a small atomic pile will be set up at the Institute in the near future, which will provide further facilities for research in

atomic physics, and also for the production of tracer elements. The scope of the work of the Institute will then be enlarged by the addition of departments for nuclear chemistry and nuclear biology.

A further series of experiments to measure the intensity of cosmic radiation at high altitudes and at great depths is also being planned, and it is intended to undertake these experiments soon.

The Institute is at present housed in temporary premises, but suitable buildings will be provided as soon as possible. The site chosen for the permanent buildings faces the picturesque harbour of Bombay, and is about a mile away from the heart of the city. It is proposed to undertake immediately the construction of two blocks of buildings, one for theoretical work, instruction and administration, and the other for experimental work on cosmic rays. The plans of these buildings will be so designed as to allow for the construction of additional blocks for nuclear physics and for housing the high-energy accelerator and its auxiliaries. The buildings will be completely air-conditioned and fitted with the latest equipment.

With the expansion of the activities of the Institute, the sponsors of the Institute believe that it will become an important centre of research in India within the next few years.

MECHANISM OF ENZYME SPECIFICITY IN THE DOMAIN OF CARBOHYDRATES

By Dr. A. GOTTSCHALK

Walter and Eliza Hall Institute of Research in Pathology and Medicine, Melbourne

IT would appear that it is the function of enzymes to reduce the energy of activation for a given reaction. How this is effected is at present unknown. There is, however, consensus of opinion that enzyme action is initiated by a union between enzyme and substrate. Bergmann[1] has advanced the theory that the enzyme protein by virtue of polar groups arranged in a pattern at its surface makes a multipoint contact with corresponding polar groups of the substrate. An intimate relationship of this kind between the interacting groups, suitably arranged in space, of enzyme and substrate may be regarded as the material basis of enzyme specificity. In most cases a single enzyme reacts with a group of substrates, though at different rates; in some cases, however, the activity of the enzyme is directed towards one substrate only. The degree of specificity of an enzyme may most properly be expressed by the decrease in the reaction velocity caused by a change in the constitution or configuration of that substrate acted upon with the highest reaction velocity (at various substrate concentrations). During the last fifteen years the effect of constitutional and configurational changes in hexoses and their glycosidic derivatives on the activity of the enzyme concerned has been extensively investigated. In view of the results of these investigations, it seems possible to derive some principles underlying enzyme specificity in the field of carbohydrates and in some instances to mark precisely the atoms or groups of the substrate which are involved in the bonding with the receiving groups of the specific enzyme protein.

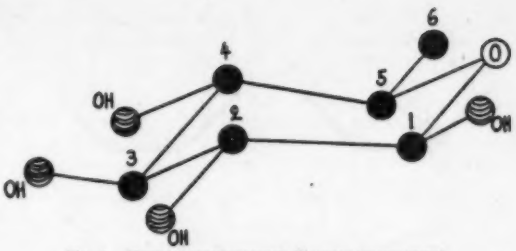


Fig. 1. Beta-glucopyranose (Sachse trans-ring)

According to recent results[2,3] the pyranose ring of *d*-glucose is of the Sachse trans (chair-shaped) form, inter-atomic distances and angles being normal within the limits of experimental error (cf. Fig. 1). In beta-*d*-glucopyranose the carbon and oxygen atoms lie in two parallel planes 0·5 A. apart, while in beta-*d*-mannopyranose the oxygen atom attached to C_2 projects about 1½ A. from the mean plane of the ring. There is rotation about the C_5-C_6 single bond, probably restricted by an energy barrier due to the attractive and repulsive forces of neighbouring groups.

Most likely the free or substituted hexose molecules approaching the enzyme will orientate themselves with the mean plane of their ring parallel to the surface of the enzyme protein, because this will provide for the greatest development of van der Waals forces between the enzyme and substrate molecules. We assume that by hydrogen bond formation or electric dipole interaction the enzyme comes into contact with at least two groups of the hexose molecule (or hexose residue), including the one which is changed in the catalytic reaction. There can be little doubt that with glycosides as substrates the oxygen atom of the glycosidic linkage is involved in the contact with an appropriate group of the enzyme protein; indeed, the reverse reaction, the enzymatic synthesis of methyl-beta-*d*-glucoside from beta-*d*-glucopyranose and methanol is scarcely conceivable without contact being established between the enzyme protein and the two hydroxyl groups the interaction of which results in the formation of the glucosidic linkage. Moreover, evidence was recently presented[4] suggesting that the enzymatic conversion into *d*-fructofuranose-6-phosphate of the alpha- and beta-forms of *d*-glucopyranose-6-phosphate and of *d*-mannopyranose-6-phosphate is catalysed by two individual hexose-phosphate isomerases. The existence of a specific mannose-6-phosphate isomerase as distinct from the glucose-6-phosphate isomerase is to be expected; for, on the above assumptions, the conversion into a common isomeride of two stereoisomeric hexose derivatives differing in the configuration at a single asymmetric carbon atom cannot be catalysed by the same enzyme. In their association with the respective enzymes, therefore, beta-hexosides (Fig. 2) are orientated with their upper side towards the surface of the enzyme protein, whereas alpha-hexosides (Fig. 4) face the enzyme with their underneath side. The primary alcohol group, due to the restricted rotation of C_6, may be able to face the enzyme irrespective of whether the upper side or the reverse side of the glucose molecule is orientated towards the catalyst.

In a series of thorough investigations, Helferich[5], Pigman[6], Weidenhagen[7], Hudson[8] and Hofmann[9] have studied the specificity requirements of the various

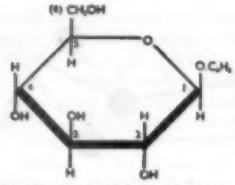


Fig. 2. PHENYL-β-d-GLUCOSIDE.

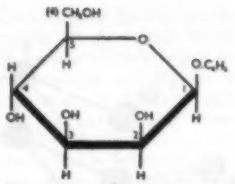


Fig. 3. PHENYL-β-d-MANNOSIDE

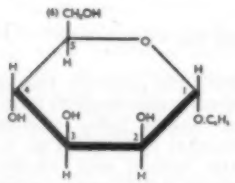


Fig. 4. PHENYL-α-d-MANNOSIDE.

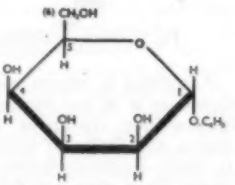


Fig. 5. PHENYL-α-d-TALOSIDE

glycosidases. It was shown that a change in the configuration at one or more ring carbon atoms or a change from the pyranose to the furanose structure renders a hydrolysable glycoside unhydrolysable by the same enzyme; for example, beta-glucosidase does not split phenyl-beta-*d*-mannoside (Fig. 3), and alpha-mannosidase is inoperative towards phenyl-alpha-*d*-taloside (Fig. 5), though these compounds differ from the specific substrates phenyl-beta-*d*-glucoside (Fig. 2) and phenyl-alpha-*d*-mannoside (Fig. 4) only in the configuration at C_2 and C_4 respectively. The effect of substitution is a different one. Thus, substitution in phenyl-beta-*d*-glucoside (Fig. 2) of the hydroxyl group at C_3 by H, F, Cl, Br or OCH_3 affects only the rate of hydrolysis by beta-glucosidase, a linear relationship obtaining between the volumes of the substituents and the logarithms of the enzyme efficiencies. Phenyl-beta-*d*-glucoside-3-methyl-ether (Fig. 6), however, is not hydrolysed by beta-glucosidase; the same holds for thiophenyl-beta-glucoside, in which compound the glucosidic linkage is effected by sulphur instead of by oxygen. Alpha-mannosidase splits phenyl-alpha-*d*-mannoside (Fig. 4) and, at much lower rates, phenyl-2-desoxy-alpha-*d*-mannoside (Fig. 7) and phenyl-alpha-*d*-lyxoside, the latter

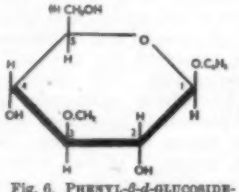


Fig. 6. PHENYL-β-d-GLUCOSIDE-3-METHYL-ETHER.

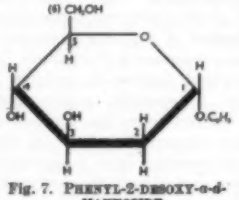


Fig. 7. PHENYL-2-DESOXY-α-d-MANNOSIDE

containing the alpha-*d*-manno-pyranose ring with the side chain $—CH_2OH$ substituted by H.

These results suggest that in beta-*d*-glucosides and in alpha-*d*-mannosides, besides the oxygen atom of the glycosidic linkage, only the hydroxyl groups attached to C_3 (beta-glucosides) and to C_4 (alpha-mannosides) respectively are available for contact with the enzyme protein. Concerning the bonding between the aglycon part of the glycosides and the enzyme, nothing definite can be said. It may be pointed out that in evaluating the results of substitution experiments it has to be borne in mind that the substituent group does change not only the molecular volume of the substrate but also the effective amount and the distribution of electric charge in the molecule. This may account for the observation that the 2, 4, 6-trimethyl derivative of phenyl-beta-*d*-glucoside does not react with beta-glucosidase (cf. also Pigman[9]).

The enzyme phosphoglucomutase, discovered by Cori *et al.*[10], catalyses reversibly the intramolecular shift of the phosphate group of alpha-*d*-glucopyranose-1-phosphate (Fig. 8) from C_1 to C_6, thus changing the glucosidic compound into glucose-6-phosphoric ester. As this enzyme does not act on alpha-*d*-mannose-1-phosphate or alpha-*d*-galactose-1-phosphate[11], which compounds have a reverse configuration at C_2 and C_4 respectively, we may assume that besides the glucosidic oxygen and the primary alcohol group at C_6, the —OH groups at C_2 and C_4 take a direct part in, or exert a decisive influence on, the association of the substrate with the enzyme.

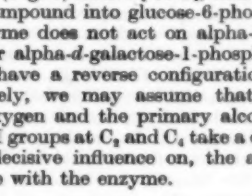
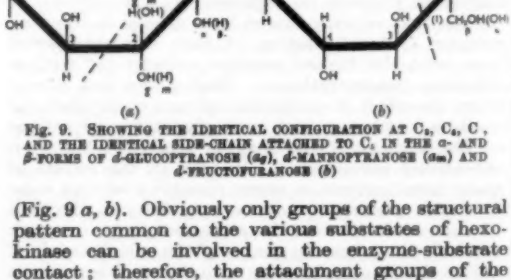


Fig. 8. α-d-GLUCOPYRANOSE-1-PHOSPHATE

The first step in alcoholic fermentation by yeast of *d*-glucose, *d*-mannose and *d*-fructose is interaction between the mobile phosphate group of adenosine triphosphate and the primary alcohol group of the individual hexose. The common catalyst of this reaction is the enzyme hexokinase[12]. It has been established in recent years that *d*-glucose and *d*-mannose are fermentable in their alpha- and beta-pyranose forms, whereas *d*-fructose is suitable for fermentation only in its furanose form[4,13-16]. In contrast to the specificity requirements of glycosidases, hexokinase tolerates rearrangements of the atoms and groups attached to the asymmetric carbon atoms 1 and 2 of *d*-glucopyranose, and moreover the fundamental change from the pyranose to the furanose structure. The alpha- and beta-modifications of *d*-glucopyranose, *d*-mannopyranose and *d*-fructofuranose have as a common feature the same side-chain and the same configuration at C_3, C_4 and C_5



(a) (b)

Fig. 9. SHOWING THE IDENTICAL CONFIGURATION AT C_3, C_4, C_5, AND THE IDENTICAL SIDE-CHAIN ATTACHED TO C_5 IN THE α- AND β-FORMS OF *d*-GLUCOPYRANOSE (*ag*), *d*-MANNOPYRANOSE (*am*) AND *d*-FRUCTOFURANOSE (*b*)

(Fig. 9 *a*, *b*). Obviously only groups of the structural pattern common to the various substrates of hexokinase can be involved in the enzyme-substrate contact; therefore, the attachment groups of the substrate may be either the —OH groups at C_3 and

C_3 or those at C_4 and C_6. A decision between these alternatives seems possible on the following reasoning. Glucose oxidase (from *Aspergillus niger*) catalyses the oxidation of *d*-glucose to gluconic acid, and at a much lower rate (1/4) it also oxidizes *d*-mannose[17]. Since in this case the hydroxyl at C_1 is one of the attachment groups, it may be concluded that a change in the configuration at a carbon atom adjacent to that carrying a contacting group greatly affects the velocity of the enzymatic reaction. Further examples supporting this conclusion can be easily presented. The hexokinase reaction with *d*-mannose as substrate proceeding only at about one third of the rate of its reaction with *d*-glucose[18], the addenda to C_2 appear to be vicinal to one of the contacting groups. Hence, the —OH groups of the substrate interacting with the receiving groups of hexokinase most probably are those at C_3 and C_4.

It would thus appear that the specificity of enzymes acting on hexosides resides in some atomic groupings arranged at the surface of the enzyme protein in a pattern able to attract the hexose residue by the glycosidic oxygen and one or more hydroxyl groups in *cis*-position to this oxygen. In addition to this bonding, attraction must be assumed for one or more groups of the aglycon part of the glycoside. Thus, the substrate molecule as a whole is appropriately orientated and fixed. The activity of glycosidases is restricted to a single type of the aldo-pyranose ring, because any change in the configuration at a ring carbon atom may remove from its proper spatial position a contacting —OH group, or produce a steric hindrance by replacing a hydrogen atom with the more voluminous hydroxyl group, or result in such a redistribution of electron charge as to eliminate the possibility of bonding between the respective groups of enzyme and substrate. There are, however, enzymes acting on hexoses, for example, hexokinase, which are less sensitive to configurational changes in the substrate. The quantitative effect on the enzyme-substrate relationship of a change in configuration at an asymmetric centre depends mainly on the spatial relation of the latter to the contacting groups. A rearrangement of the hydrogen and hydroxyl group at a carbon atom adjacent to an attachment group of the substrate invariably affects seriously the rate of the enzymatic reaction. When, however, the same configurational change takes place at a carbon atom more distant from the contacting groups, the effect on the enzyme-substrate relationship is much less marked.

[1] Bergmann, M., Harvey Lectures, **31**, 37 (1936).
[2] Cox, E. G., and Jeffrey, G. A., *Nature*, **143**, 894 (1939).
[3] Beevers, C. A., and Cochran, W., *Nature*, **157**, 872 (1946).
[4] Gottschalk, A., *Biochem. J.*, in the press.
[5] Helferich, B., *Ergeb. Enzymforsch.*, **7**, 83 (1938).
[6] Pigman, W. W., "Advances in Enzymology", **4**, 41 (1944).
[7] Weidenhagen, R., *Ergeb. Enzymforsch.*, **1**, 168 (1932).
[8] Adams, M., Richtmyer, N. K., and Hudson, C. S., *J. Amer. Chem. Soc.*, **65**, 1369 (1943).
[9] Hofmann, E., *Biochem. Z.*, **272**, 133, 426 (1934).
[10] Cori, C. F., and Cori, G. T., *Proc. Soc. Exp. Biol. and Med.*, **34**, 702 (1936). Cori, G. T., Colowick, S. P., and Cori, C. F., *J. Biol. Chem.*, **123**, 375 (1938).
[11] Cori, G. T., Colowick, S. P., and Cori, C. F., *J. Biol. Chem.*, **124**, 543 (1938).
[12] Meyerhof, O., *Biochem. Z.*, **183**, 176 (1927).
[13] Gottschalk, A., *Austral. J. Exp. Biol.*, **21**, 133, 139 (1943).
[14] Gottschalk, A., *Austral. J. Exp. Biol.*, **23**, 261 (1945).
[15] Gottschalk, A., *Biochem. J.*, **40**, 621 (1946).
[16] Gottschalk, A., *Biochem. J.*, in the press.
[17] Mueller, D., *Biochem. Z.*, **205**, 111 (1929).
[18] Berger, L., Slein, M. W., Colowick, S. P., and Cori, C. F., *J. Gen. Physiol.*, **29**, 379 (1946).

OBITUARIES

Prof. C. A. Kofoid

Less than two months after the death of H. S. Jennings (see *Nature*, June 21, p. 834), America has lost another—and almost the last—of her elder workers on the Protozoa. Prof. C. A. Kofoid died—also in California—after a heart attack on May 30 at the age of eighty-one.

Charles Atwood Kofoid was born at Granville (Illinois) on October 11, 1865, and took his first degree (A.B.) at Oberlin College in 1890. He then moved to Harvard, where he graduated A.M. (1892) and Ph.D. (1894). After a short period of teaching at Michigan (1894–95), he was appointed superintendent of the Illinois Biological Experiment Station, where he remained for five years. Finally, he gravitated to the centre of his chief scientific activities—the University of California, where he became assistant professor of zoology in 1900, and professor and director of the department in 1910. He remained at this post for more than a quarter of a century, when he retired (1936) as professor emeritus.

Kofoid was a zoologist of wide interests, but devoted his great energies particularly to marine zoology, protozoology, and parasitology. He was always attracted by planktonic organisms, and while at Illinois published papers on the phytoflagellates of the Illinois River. Later, at California, he took a leading part in establishing the Marine Biological Station (now the Scripps Institution of Oceanography) at San Diego, and produced a notable series of memoirs on the dinoflagellates of that region. These were followed by exhaustive systematic monographs on the Unarmoured Dinoflagellata (with O. Swezy, 1921), the Dinophysoidæ (with T. Skogsberg, 1928), the Tintinnidæ (with A. S. Campbell, 1929), and the Heterodiniidæ (with A. M. Adamson, 1933). Earlier, he published a detailed survey of all "The Biological Stations of Europe" (1910). In the field of applied zoology, with which he was always concerned, he played an active part on various committees for studying the damage done by the shipworm (the mollusc *Teredo*: reports published in 1924 and 1927), and also that caused on land by termites (final report published in 1934); and with his pupils he paid much attention to the wonderful flagellate Protozoa living in these remarkable insects.

Towards the end of the First World War Kofoid was appointed major in the U.S. Sanitary Corps, and threw himself with enthusiasm into the study of human intestinal Protozoa. A long series of papers by himself and his collaborators was the result. But unfortunately he approached this intricate and tricky subject without sufficient previous experience, and consequently most of his 'discoveries' and all his 'new' genera and species are now known to be misinterpretations. To the end of his life, however, he refused to give them up. In his later years he also became interested in the history of biology, and during the last decade wrote many reviews for *Isis*. He left a large library, which is housed in the University of California at Berkeley.

Kofoid will be specially remembered for his fundamental share in developing the Zoology Department of the University of California to its present distinguished status, and for his editorial work in connexion with the "University of California Publications in Zoology". These contain many important papers—including many by himself and his pupils—

which are familiar to all zoologists. His own publications are too numerous to mention in more detail, but together they constitute an integral part of the output of protozoological research in the United States during the last fifty years.

CLIFFORD DOBELL

Prof. A. W. Stewart

EMERITUS PROF. ALFRED WALTER STEWART died at his residence in Belfast on June 30, after many years of indifferent health borne with stoical courage.

The youngest son of the late Prof. William Stewart, Dean of Faculties in the University of Glasgow, he was educated at the University of Glasgow, the University of Marburg and University College, London, and had held in turn the lectureship in organic chemistry at Belfast and the lectureship in physical chemistry and radioactivity at Glasgow. In 1919 he succeeded the late Prof. Letts as professor of chemistry at Belfast. During his tenure of office in Queen's University, Stewart did much to create the school from which many of his students went to occupy important positions in industrial and academic life at home and abroad. He was a man of great learning, gifted with a fertile imagination, and laboured continually to provide a sound and fundamental training in all branches of modern chemistry. He was ever ready to give counsel to those who sought his advice, and was deeply interested in the welfare of his students.

Stewart had a special interest, born from his close association with Ramsay and Collie, in the application of physical chemistry to the elucidation of the structure and properties of organic compounds, and his work upon Tesla-luminescence spectra was especially noteworthy. He and his co-workers developed a new field of spectroscopy by employing a fresh method of excitation to reveal series of spectra each of which is characteristic of the compound which emits it, and so added a new constitutional property to those previously known.

His love of investigation and his interest in the teaching of chemistry are revealed in his many writings, notably the volumes in his series of "Recent Advances in Physical, Inorganic and Organic Chemistry", which have reached many editions. He had pleasure in recalling that he had directed attention to the elements which had identical atomic weights but which differed in chemical properties and to which he gave the name 'isobars'. Since his retirement in 1944 from the chair of chemistry in the Queen's University of Belfast, which he had occupied for twenty-five years, he had devoted himself to his literary work with increased pleasure and devotion.

To have been one of Stewart's intimate friends is a privilege and a cherished memory; of a shy and retiring disposition, he avoided all forms of ostentation, and only those who had his confidence can appreciate the kindly nature, the tender affection and the stimulating effect of an evening spent with him by his fireside. Stewart's work—both as a man of science and an author—was characterized by meticulous care and thoroughness. His interests were catholic and his learning wide. British science is poorer by his loss, and another link has been severed with the pioneers of the early years of this century.

During his years of ill-health, borne with great fortitude, he had the constant companionship of his wife and only daughter, to whom sympathy is extended in their loss.

D. N. MCARTHUR

Prof. G. E. M. Jauncey

DR. GEORGE ERIC MACDONNELL JAUNCEY, professor of physics at Washington University, St. Louis, Missouri, died on May 19 at his home in St. Louis. He was born in South Australia in 1888, and educated at the University of Adelaide; later he did graduate work under Sir William Bragg at the University of Leeds. He held instructorships in physics at Toronto, Lehigh, Missouri, and Iowa State College. In 1920 he joined the department of physics at Washington University and became professor of physics in 1930, a position which he held at the time of his death.

During the twenty years following his appointment, Jauncey carried out research on many phases of X-ray scattering, the results of which are to be found in numerous communications in the *Physical Review* and other journals. He was also deeply interested in students and the problems of teaching physics at all levels. Out of his interest in teaching undergraduates at an intermediate level resulted his widely used book "Modern Physics", which has passed through three editions.

A severe illness in 1940 resulted in a permanent impairment in his health, which made it impossible for him to continue experimental work. He then turned his attention to the history of physics. The papers which he had published were to have been followed by others in this field had he lived to work out his programme.

A. L. HUGHES

Prof. G. Matthai

WE regret to announce the death at Cambridge on June 25 of Prof. George Matthai, formerly of the Indian Educational Service and emeritus professor of zoology in the University of the Punjab at Lahore. Dr. Matthai succeeded the late Lieut.-Colonel J. Stephenson as professor of zoology at Lahore in 1919. Under Stephenson the Lahore School of Zoology had been raised to a high degree of efficiency and was *facile princeps* among the Indian Schools; Prof. Matthai worked hard to maintain this proud position, though of late years Lahore has been challenged and has had to yield pride of place to Lucknow. Prof. Matthai would under normal conditions have retired in 1942, but as a war measure his term of office was extended until 1945.

Prof. Matthai was a recognized authority on corals, and as Mackinnon Student he had worked on the coral reefs of the West Indies: he also studied the corals and reefs of the Indian and Ceylon regions. He revised the classification of the Astræidæ and published several valuable monographs, the most important of which was the British Museum Catalogue of this family (1928). Negotiations were in progress to enable him to undertake the preparation of a similar monograph on the Fungiid Corals. His death is a great loss to systematic and taxonomic zoology.

R. B. SEYMOUR SEWELL

WE regret to announce the following deaths:

Prof. Noah Morris, regius professor of materia medica and therapeutics in the University of Glasgow since 1937.

Dr. Wilfred H. Osgood, emeritus curator of zoology in the Field Museum of Natural History, and a corresponding member of the Zoological Society of London, aged seventy-one.

Dr. John Parkinson, well known for his work in economic geology in many parts of the British Empire and elsewhere, on July 19, aged seventy-five.

NEWS and VIEWS

Prof. E. P. Cathcart, C.B.E., F.R.S.

PROF. E. P. CATHCART retires from the regius chair of physiology, University of Glasgow, this summer after having completed almost twenty years service in the senior chair of the Institute of Physiology. The previous nineteen years he spent as Gardiner professor of physiological chemistry in the same Institute. Cathcart matriculated as a student in 1895 and graduated M.B., Ch.B. in 1900. Four years later he took his M.D., and in 1906 received the degree of D.Sc. Periods of foreign study were passed in Munich, Berlin and Petrograd (with Pavlov), and with F. C. Benedict at the Carnegie Institution at Boston. It was in 1905 that Cathcart was appointed Grieve lecturer in physiological chemistry in his *alma mater*: then from 1915 until 1919 he was professor of physiology in the London Hospital Medical School. During the First World War he occupied an important post in our anti-gas measures and held the rank of lieutenant-colonel. Afterwards he became a member of the Army Advisory Committee on Nutrition and on Hygiene. He was also a member of the Technical Committee on Nutrition of the League of Nations, and served on the Medical and Agricultural Research Councils. He was for many years a member of the General Medical Council. Among the other posts which he has held, his chairmanship of the Industrial Health Research Board and of the Scottish Health Services Committee are probably the most outstanding.

Cathcart's main lines of inquiry have been directed to the study of the physiology and efficiency of muscle work, and to the physiology of starvation and protein metabolism. His inquiries into the national diet and those of its constituent classes were models of their kind, and his advice was much sought after by Government departments. His most important publication was probably his monograph on "The Physiology of Protein Metabolism". Many have regretted that he did not publish editions other than the first. Cathcart belongs to the now very small group of men who have a wide interest in physiology in all its branches. He has a rare gift of inspiring and encouraging the best efforts of his junior colleagues. To the outsider he has always presented a rather gruff exterior, and he did not tolerate fools gladly; once admitted to his friendship, he was the staunchest of friends. In 1913 Prof. Cathcart married Miss Gertrude Norman Bostock, herself a doctor and one who has contributed to the physiology of metabolism in papers to the *Biochemical Journal*. She has been a most devoted and active wife, and her contribution to the welfare work of the University of Glasgow Settlement has been outstanding.

Prof. R. C. Garry

PROF. ROBERT CAMPBELL GARRY has been appointed to succeed Prof. Cathcart in the regius chair of physiology at Glasgow. Prof. Garry, who was the most distinguished graduate of his year (1922) in the University of Glasgow, obtaining his M.B., Ch.B. degree with first class honours, has held the chair of physiology at University College, Dundee, since 1935. After a period of training both in research and teaching in the Physiology Laboratory of the University of Glasgow and at Freiburg under the late Prof. Paul Trendelenburg and with Prof. Lovatt Evans at University College, London, he was appointed in 1933 head of the Physiology Department of the Rowett Institute in Aberdeen. This post he held until his promotion to Dundee. Prof. Garry has had considerable experience in administration work, as he has served for two terms of three years as assessor on the University Court of the University of St. Andrews and as an elected representative on the Council of University College, Dundee. He has always, since his earliest days in the Physiology Department of the University of Glasgow, been interested in the popularization of science, and was one of the pioneer lecturers in physiology to classes organised by the Workers Educational Association. This work, as well as his series of school broadcasts, was most successful. Prof. Garry has always been a keen research worker; in his early days his activities were directed to applied physiology, and latterly they have in the main been turned to general experimental work, particularly to the relation of the caudal region of the large bowel, and more recently to problems of nutrition. He is an editor of the newly founded *British Journal of Nutrition*. Prof. Garry was elected in 1943 a member of the editorial board (and is now chairman of the board) of the *Journal of Physiology*. He was elected a fellow of the Royal Society of Edinburgh in 1936 and was a member of its Council during 1938–41.

East African Institute of Social Research: Lieut.-Colonel W. E. H. Stanner

THE Secretary of State for the Colonies has appointed Lieut.-Colonel W. E. H. Stanner to be director of an East African Institute of Social Research, the establishment of which is to be financed from a grant of £66,915 made in November 1945, under the Colonial Development and Welfare Act. The Institute will be associated with Makerere College, Uganda, which is being developed into the University College of East Africa. Colonel Stanner, an Australian, who is forty-one years old, is a graduate of the University of Sydney and a Ph.D. of the University of London (London School of Economics). He has carried out extensive field research in social anthropology in northern Australia and in Kenya. Recently, he has been engaged on research in the South Pacific on behalf of the Institute of Pacific Relations.

Redwood Medal of the Institute of Petroleum

THE Redwood Medal of the Institute of Petroleum has been awarded to H. S. Gibson, general fields manager, Anglo-Iranian Oil Co., Ltd., Abadan, for his unique work on the production of petroleum. Established in 1921 in honour of Sir Boverton Redwood, founder-president of the Institute, the Redwood Medal is awarded "to a petroleum technologist of outstanding eminence, irrespective of nationality or membership of the Institute". Only seven previous awards have been made since the medal was instituted, the last being in 1938. Mr. H. S. Gibson served in the First World War in France, Egypt, Salonica and Turkey, and was mentioned in dispatches. On demobilization in 1919 he went to Emmanuel College, Cambridge, where he took the Mechanical Science Tripos. In 1922 he joined the (then) Anglo-Persian Oil Co., Ltd., as production engineer, and advanced steadily until in 1945 he was made general fields manager. He was awarded the C.B.E. in this year's King's Birthday honours.

Detection by Radar of a New Meteor Shower

British Astronomical Association Circular No. 282 gives a short note from Dr. A. C. B. Lovell, director of radar research on meteors at the University of Manchester, who has announced the discovery of a new shower during daylight. For some time radio reflexion has been used to study the ionization caused by meteors in the upper atmosphere (see *Nature*, July 19, pp. 74 and 76). Certain radiants have been selected and studied carefully by means of a beam of radiation about ± 6° wide which can be directed to any point in the heavens, and Mr. J. A. Clegg has devised a method by which it is possible to determine very accurately the radiant of a stream. No details about this method have been published up to the present, but it may be assumed that it is capable of providing more accurate results than those obtained from visual observations. It is interesting to know that the investigation of the radiants of the well-known showers during the autumn and winter shows, apart from minor variations, that the radiants determined by Mr. J. P. M. Prentice, director of the Meteor Section, British Astronomical Association, and his colleagues, agree closely with those found by Mr. Clegg's method.

The investigation of the η Aquarid stream was commenced on May 1, and it was obvious that this well-known stream was merely the beginning of a very active belt stretching towards the sun, the main radiant point of this stream lying in the constellation of Pisces. As this latter radiant crossed the meridian at about 10h.–11h., depending on the period of observation in May, no knowledge of this shower was possible from visual observation. The Aquarius end of this belt disappeared in mid-May; but the Piscid radiant continued with great intensity, and on June 22 the shower, which had continued for 35 days, was still active, the radiant being now in Taurus, and showed no signs of ending. While fluctuations in intensity have occurred, the hourly rate at transit has often exceeded 80 and has never fallen below 20. Preliminary analysis has given the following approximate positions of the new radiant:

May 7	R.A. 1h. 20m.	N. Dec. 20°–25°
June 22	4 40	20 –25

Minor radiants have also appeared for a few days about 15° W. and 10° E. of the main knot, but at the same declination, and on some occasions the whole area between these extremes has been active.

Institutum Divi Thomæ: Extension of Facilities

THE Donner Foundation, Inc., the head of which is William H. Donner, of Philadelphia, has given a 64-room building in Palm Beach, Fla., to the Institutum Divi Thomæ, of Cincinnati, Ohio, for scientific research. The building, to be known as Donner Hall, was formerly a part of the estate of the late Colonel E. R. Bradley, and is adjacent to Bradley Hall, now occupied by the marine biological laboratories of the Institutum Divi Thomæ. Dr. George S. Sperti, director of the Institutum, states that Donner Hall will provide quarters for what is planned eventually to be the largest marine biophysics laboratory in the world; the Institutum already maintains a floating laboratory, the *Aquina*, which will become part of this programme. Secondly, since cancer in its simplest terms is a problem in cell division, and since lower forms of sea life offer convenient material for studying cell reproduction, Donner Hall will provide for intensive fundamental research in cancer. Finally, it will provide quarters for visiting scientific workers from various parts of the world, who will be invited to participate in a series of symposia devoted to different fields of research. The Institutum Divi Thomæ, founded in 1935 by the Most Rev. John T. McNicholas, Archbishop of Cincinnati, as a graduate research school, open to all scientific workers regardless of race, colour or creed, now has fourteen affiliated units throughout the United States; it has already been responsible for important work in various fields, notably biochemistry and biophysics. William H. Donner, whose generosity has opened the way to the establishment of the new cancer research centre, has previously given large sums for the study of cancer. He was born in Columbus, Ind., in 1864, and is a Presbyterian. Beginning as treasurer of the National Tin Plate Company at Anderson, Ind., Mr. Donner built its plate works near Pittsburgh and founded Monessen, Pa., before the company was absorbed by the American Tin Plate Company. He then built up another steel corporation in the same way until it became part of the Union Steel Company, which in turn was purchased by the United States Steel Corporation.

Television in the United States

THE Radio Corporation of America has played a prominent pioneer part in the practical development of television in the United States, more particularly since 1923, when Dr. V. K. Zworykin applied for a patent on the now world-famous iconoscope. Much of this pioneer work has been inspired by Brigadier General Sarnoff, president of the Radio Corporation of America, and it is the purpose of an illustrated booklet recently issued by the Information Department of the Corporation (New York, 20) to present excerpts from General Sarnoff's statements on the subject at various public meetings and demonstrations during the past twenty-four years. Much of the results of the work conducted in the research laboratories of the R.C.A. is described in scientific and technical papers published in various journals, including the *R.C.A. Review*, to which reference was made in *Nature* of September 14, 1946 (p. 373). The publishers of this *Review* have now issued a bibliography of technical papers on television by R.C.A. authors. This includes some 275 technical papers on television and closely related subjects published during the period 1929–46, and arranged generally in chronological order. This "Television Bibliography" is in the same handy size (about 9 in. × 6 in.) as the *R.C.A. Review*, and should prove useful and convenient to all those concerned with the study, development and application of television. It is to be regretted that while the references give the year and month of publication, they do not give the volume and page number of the journal in question.

Mesozoic Faunas of Peru

IN 1941, Dr. William F. Jenks sent rich collections of fossils, made in the course of his field work in the Cerro de Pasco region of central Peru, to Dr. Otto Haas, of the American Museum of Natural History, New York, for identification. Ever since, a steadily increasing amount of Peruvian fossil invertebrates has been accumulating at the Museum. Collections made during 1943–46 by Dr. Norman D. Newell in central, eastern and southern Peru, by Mr. Bernhard Kummel in northern, central and eastern Peru, and by Dr. Jenks in southern Peru have since been added

to that initial material, and it is hoped that additional collections will be brought in by a forthcoming expedition to Peru under Dr. Newell's leadership. Besides Palæozoic assemblages, to be studied and published separately, most of those collections are of Mesozoic age. The work of description is being divided among several specialists. So far, Dr. Raymond E. Peck and Mr. Reker have just finished a report on charophytes from various regions and horizons, intended for publication in the American Museum *Novitates*, Dr. John W. Wells will study the Anthozoa and Porifera, Dr. Newell has taken charge of the pelecypods, and Dr. Kummel will concentrate on Triassic cephalopods. Dr. Haas is studying the Post-Triassic cephalopods and the gastropods. Some important groups, especially the brachiopods, which are second only to the molluscs in number of specimens, are still waiting for specialists to undertake their study. The Instituto Geológico del Perú, the director of which is Dr. Jorge Broggi, is co-operating with the American Museum of Natural History in all this work.

Royal Commission for the Exhibition of 1851 : Overseas Scholarships 1947

THE Commissioners of the Royal Commission for the Exhibition of 1851 announce the award of Overseas Science Research Scholarships for 1947 to the following, the recommending body appearing in brackets : E. Gorham (Dalhousie University, Halifax), for research in plant ecology at University College, London ; W. A. Bryce (McGill University, Montreal), for research in physical chemistry at the University of Oxford ; C. C. Costain (University of Saskatchewan), for research in physics at the University of Cambridge ; D. R. Bowes (University of Adelaide), for research in geology at the Imperial College of Science and Technology, London ; L. Riddiford (University of Melbourne), for research in physics at the University of Birmingham, or the University of Manchester ; Miss June Lascelles (University of Sydney), for research in biochemistry at the University of Oxford ; J. N. Dodd (University of New Zealand), for research in physics at the University of Birmingham ; J. P. Teegan (National University of Ireland), for research in physical chemistry at the University of Cambridge ; Dr. A. K. Saha (University of Calcutta), for research in physics at the University of Birmingham ; Dr. A. B. Bhatia (University of Allahabad), for research in physics at the University of Bristol.

Leverhulme Research Fellowships : Awards for 1947

THE following awards, among others, for research in the subject mentioned and tenable for periods up to two years, have been announced by the trustees of the Leverhulme Research Fellowships : *Fellowships :* R. C. Abraham, late district officer, Nigeria, modern languages of Ethiopia and Eritrea (renewal) ; Dr. R. Dennell, reader in experimental zoology, University of Manchester, structure and physiology of the luminous organs of the Decapoda ; J. A. Ratcliffe, lecturer in physics, University of Cambridge, propagation of radio waves ; Dr. R. Stoneley, lecturer in mathematics, University of Cambridge, elastic yielding of the earth. *Research Grants :* Dr. P. Allen, demonstrator in geology, University of Cambridge, comparative petrology and palæoecology of the European 'Wealden' ; J. S. Barlee, biology master, Royal Naval College, Dartmouth, investigation into the status of certain birds in Ireland ; Miss E. M. Brown, lecturer in zoology, Chelsea Polytechnic, London, parasitic dinoflagellates and other causal organisms of disease in fish ; Dr. J. G. D. Clark, lecturer in archæology, University of Cambridge, economic and social prehistory of Europe since late Glacial times ; J. S. Gittins, principal, Aycliffe Approved School, Darlington, a survey of the mental characteristics of delinquent boys ; Dr. J. Grant, medical officer of health, County Borough of Gateshead, a study of epidemic diphtheria ; Dr. F. R. Irvine, administrative officer, Faculty of Science, University of Edinburgh, indigenous plants of West Africa and their utilization for local purposes ; P. Slater, principal research officer, Social Survey, use of statistical methods in forecasting human behaviour. Information in connexion with Leverhulme awards can be obtained from the Secretary, Leverhulme Research Fellowships, 7 Bedford Row, London, W.C.1.

The Night Sky in August

FULL moon occurs on August 2d. 01h. 50m. U.T. and new moon on August 16d. 11h. 12m. The following conjunctions with the moon take place : August 12d. 22h., Mars 2° S. ; August 15d. 10h., Mercury 4° S. ; August 22d. 18h., Jupiter 0·1° N. In addition to these conjunctions with the moon, Mercury is in conjunction with Jupiter on August 18d. 13h., Mercury being 0·6° N. Mercury rises 1h. 22m. before the sun on August 1, but will not be an easy object to observe. It attains its greatest western elongation on August 3, and at the end of the month is a morning star, rising only 10 minutes before the sun. Venus rises 50 minutes before the sun on August 1 and practically at sunrise on August 31, and will not be well placed for observation during the month. Mars, in Gemini, is visible in the early morning hours, rising soon after midnight during most of the month. Jupiter, in the constellation of Libra, is visible in the early portion of the night, setting at 23h. and 21h. 06m. at the beginning and end of the month, respectively. Saturn, in conjunction with the sun on August 5, cannot be seen. The following occultations of stars brighter than magnitude 6 take place : August 14d. 03h. 21·5m., *A* Gemi. (*R*) ; August 24d. 20h. 29·0m., 88 *B* Ophi. (*D*). *R* and *D* refer to reappearance and disappearance, respectively, and the latitude of Greenwich is assumed. The Perseid shower of meteors attains its maximum about August 10–12 ; the radiant is close to R.A. 3h., Dec. + 57°.

Announcements

THE opening on July 14 of an Exhibition at the Science Museum, South Kensington, arranged with the Chemical Society, the eleventh International Congress of Pure and Applied Chemistry and the Department of Scientific and Industrial Research to illustrate the achievements of British chemists during the past century and to show the uses of chemistry in everyday life, marked the beginning of the centenary celebrations of the Chemical Society. The exhibition is now available to the general public, and will remain open until September 30 (weekdays, including August Bank Holiday, 10 a.m.–6 p.m. ; Sundays, 2.30 p.m.–6 p.m.).

DR. ADRIEN ALBERT, who for the last nine years has been working at the University of Sydney on the physics and chemistry of drug action, has joined the staff of the Wellcome Research Institution, London, to initiate similar studies there.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

An Example of 'Mimicry' in Fishes

Among the genera of Cichlid fishes peculiar to Lake Nyasa, *Corematodus*, comprising two species, is characterized by the dentition, which consists in each jaw of a broad file-like band of small pointed teeth. Otherwise these two species would be included in the large genus *Haplochromis*, of which more than a hundred, nearly all endemic, have been recorded from Nyasa. Among the *Haplochromis* and their related genera in Nyasa, many species have a colour pattern characteristic of the Lake and rarely met with elsewhere in Africa, namely, a dark oblique band from nape to caudal fin. *Corematodus tæniatus* Trewavas also has this pattern on a silver-grey ground; the largest specimen known is 19 cm. in total length. *C. shiranus* Blgr. has quite a different pattern, consisting of vertical, or nearly vertical, black bars extending from the back to near the ventral surface. This pattern is exactly similar to that of females and non-breeding males of the Nyasa species of *Tilapia* of the *T. squamipinnis* group; and *C. shiranus* reaches a length of 27 cm., which is one of the commonest lengths of the *T. squamipinnis* caught during the Fishery Survey of 1939 [1].

The guts of six specimens of each species of *Corematodus* were examined. The intestine is long, narrow and coiled. In each case stomach and intestine contained nothing but hundreds of minute scales exactly like those which cover the caudal fin of so many Cichlid species of Lake Nyasa, including *Tilapia squamipinnis*. The efficacy of the double file of the jaws of a *Corematodus* in rasping scales from the caudal fin of a *Tilapia* can easily be demonstrated, and except for the loss of some scales, the tail can be pulled undamaged from between the closed jaws. It seems that *Corematodus* specializes in this curious diet.

The strong superficial resemblance of *C. shiranus* to *T. squamipinnis* must be very useful to the former, enabling it to swim unnoticed in the shoals of *Tilapia*. The relationship between the two fulfils the conditions required of model and mimic. *Tilapia* is abundant and swims in shoals, *Corematodus* is relatively rare and is solitary, and reaps the advantage of the resemblance.

It was not found possible to identify the scales in the gut of either species of *Corematodus* as being those of *Tilapia* or of one of the *Haplochromis* group. It would be interesting to know if the two species do, in fact, select as victims fishes resembling them respectively in colour-pattern. The *Corematodus* seen were caught singly, in hauls including numerous *Tilapia* and also some oblique-banded Cichlids.

The two species of *Corematodus* were exhibited some years ago with the species they resemble by Dr. Tate Regan, but until 1939 their habits, which give point to the mimicry, were unknown.

Ethelwynn Trewavas

British Museum (Natural History),
London, S.W.7.
May 13.

[1] Ricardo Bertram, C. K., Borley, H. J. H., and Trewavas, E., Report on the Fish and Fisheries of Lake Nyasa (1942); see p. 28 and p. 60.

A Fungus Parasitic on *Coptotermes curvignathus*, Holmgr.

During the course of some observations designed to determine the most suitable conditions for maintaining the workers of *Coptotermes curvignathus* (the termite pest of *Hevea brasiliensis*) in captivity, the development of an unusually high death-rate in one of the treatments led to an examination which disclosed that the insects had been parasitized by an entomophthoraceous fungus. The causal organism was isolated, and cultivated without difficulty on standard media and on rice-bran.

Its ability to parasitize and kill *Coptotermes* workers has been established experimentally; a 100 per cent kill being obtained within 48 hours in trials in which the insects (maintained in Petri dishes on sterile soil) were supplied with infected rice-bran as a source of food, the presence of the characteristic hyphæ in the tissues of the insects confirming the cause of death. The mortality in the controls, fed on sterile bran, was 3 per cent during the same period.

Reference to the literature suggests a relationship between this parasite and the species of *Conidiobolus* isolated from *Nasutitermes* by Kevorkian in Cuba[1]. The Imperial Mycological Institute, to which a culture was sent, considers, however, that the Malayan fungus does not completely agree with the Cuban fungus as that was described; in particular, the primary conidia of the first measure distinctly larger, and it has not been observed to form the structure termed 'villose resting spores'. Pending comparison with authentic material, it is regarded tentatively as a new species of *Conidiobolus*.

R. A. Altson

Rubber Research Institute of Malaya,
Kuala Lumpur, Malaya.
March 28.

[1] Kevorkian, A. G., *J. Agric. Univ. Puerto Rico*, **21**, 191 (1937).

A Disease of Pyrethrum in Kenya

The demand for pyrethrum (*Chrysanthemum cinerariifolium*) resulted in a greatly increased production of this profitable crop in Kenya during the War. It has been cultivated commercially in Kenya since 1928. From 1,864 tons in 1938, the yield rose to 7,409 tons from 52,837 acres in 1945. This acreage is concentrated in a few areas in the Highlands, most of it at an altitude between 6,000 ft. and 9,000 ft. Minor losses, due to root and crown rot, are of common occurrence, but until 1946 the crop had escaped any serious disease in spite of the continuous and intensive cultivation to which it has been subjected.

The most important of the higher yielding areas is on the Mau Escarpment, where in June 1946 a serious falling off in yield, estimated in some instances to be as high as 80 per cent, occurred. Although the plants themselves appeared healthy, the flower buds failed to develop on account of an attack by the fungus *Ramularia bellunensis* Speg.[1]. By the end of the year, the disease had spread to all the main pyrethrum areas with the exception of the Nyeri – Nanyuki area on the slopes of Mount Kenya, which, up to the time of writing, had remained free.

Although typically a disease of buds and flowers (see illustration), rarely extending beyond the apical inch or so of flower stalk, the disease has been found infrequently on the foliage. Here no definite spots are formed, but the infection starts from the tip of the leaf segments and extends inwards.

Ramularia bellunensis Speg. on *Chrysanthemum cinerariifolium*. × 2 approx.

R. bellunensis has been recorded as causing a disease of *Chrysanthemum frutescens* in Italy in 1929 [2] and in England in 1938 [3]. In Italy, leaves and unopened inflorescences of pot plants in a greenhouse were severely affected. In England, the foliage in all stages was attacked, the lesions extending inwards from leaf tip and margin. The fungus does not appear to have been recorded on *C. cinerariifolium*, although both the fungus and this host are believed to be endemic in the Mediterranean region.

The immersed stromatic bodies from which the conidiophores arise are abundantly developed on the inner surfaces of the involucral scales, fragments of which are readily distributed with the seed.

This is, perhaps, another example of an exotic fungus finding a ready victim and a more congenial environment than hitherto recorded. Its advent is regarded by the pyrethrum industry of Kenya with apprehension.

R. M. Nattrass

Department of Agriculture,
Nairobi, Kenya Colony.
April 21.

[1] Det. Imperial Mycological Institute.
[2] Voglino, P., L'avvizimento fogliare della Margherita bianca.—La Difesa delle Piante, VI, 3, 1 (1929) (extract R.A.M. VIII, 723).
[3] Oyler, Enid, Plant Diseases, Rep. Exp. Res. Sta. Cheshunt (1937) (extract R.A.M. XVII, 583).

Meiosis in Bougainvillea

A query concerning the possibilities of crossing various horticultural varieties of Bougainvillea led me to examine meiosis in several of the more important ones available in Jamaica. Six varieties, Snow White, Formosa, Dark Purple, Ruby, Orange King and Royal Purple, were used. The first three have been assigned to the species *Bougainvillea glabra*, the next two to *B. spectabilis*, and the last is reputed to be a cross between unknown *glabra* and *spectabilis* types. In all six varieties, the chromosome number was found to be $2n = 34$. None of the available chromosome number lists gives any number for *B. spectabilis*, but Darlington and Ammal[1] list *B. glabra* as $2n = 20$. Since a counting error of 14 chromosomes is unlikely, it seems probable that the horticultural glabrous types are not directly derived from the true *B. glabra* but are species hybrids resulting from doubling in an $(x = 10) \times (x = 7)$ type. There is, however, little direct evidence for this assumption.

Cytologically, four of the varieties studied behave as regular diploids with 17^{II} at first metaphase and subsequent normal segregation (see table). All four are also fertile but apparently not completely so, as the seed set under natural conditions is not high. The remaining two types, Ruby and Orange King (the latter of which is reputedly a bud sport of the former), are meiotically irregular with most first metaphase plates showing from four to six univalents. These univalents follow the bivalents to the plate and then split. Of the resulting chromatids, about a third fail to be included in the daughter nuclei, but ultimately give rise to micro-nuclei in the tetrads. Chromatids included in the first telophase nuclei split again at second anaphase, but complete separation often fails and thus gives rise to second anaphase chromatin bridges. Both Ruby and Orange King appear to be completely sterile.

It is therefore tentatively assumed that the horticultural varieties of Bougainvillea are amphidiploids, and that a species (*B. spectabilis* ?) with a basic number of $x = 7$ should exist. In view of the horticultural importance of this genus, further investigation is indicated.

G. B. Wilson
(Botanist)

Department of Agriculture,
Jamaica, B.W.I.

[1] Darlington, C. D., and Ammal, E. K. Janaki (Allen and Unwin, London, 1945).

Meiosis in Bougainvillea

Species	Variety	X	$2n$	Fertility	Meiosis type	Remarks
B. glabra	Formosa	17	34	Fertile	Regular 17^{II} with normal segregation at divs. I and II	
	Snow White	17	34	"	" " "	
	Dark Purple	17	34	"	" " "	
B. spectabilis	Ruby	17	34	Sterile	Irregular with 4–6[I] at M^{I}	Univalents split at first anaphase. About ½ excluded from nuclei
	Orange King	17	34	"	" " "	" " " "
	Royal Purple	17	34	Fertile	Regular with 17^{II} at M^{I}	

A Rapid Nigrosine Method for Chromosome Counts Applicable to Growing Plant Tissues

For a plant-breeder dealing with plants which can be cross-fertilized who desires to work up polyploid material on a large scale, annual control of the purity of the polyploid stocks as regards chromosome number is necessary. A breeder of fruit and forest trees should also have at his command methods by which the chromosome numbers in new artificial or spontaneous crosses can be simply separated.

A grading of the polyploid chromosome number groups only requires an estimation of the number of chromosomes in the genome (for example, in *Beta*, 36 ± 2–4). Further, chromosome counting should be possible at any time in the whole vital cycle of the plants (including pollen mother-cells) and by the same simple method. In the method described below the treatment is essentially the same for roots as for leaves and flower-buds. Any deviations between them are noted in their proper connexion.

Fixing. Fix in 1 part of concentrated (98 per cent) acetic acid + 2 parts of 95 per cent alcohol for about 24 hours. Roots should be fixed in a cooled fluid.

Loosening of the tissues. Replace the fixing fluid with a cooled mixture of 1 part of concentrated hydrochloric acid (sp.gr. 1·27) + 2 parts of 95 per cent alcohol. Roots are treated for 8–10 min. For leaves the character of the tissues will decide the concentration and time: *Beta*, 1 : 2 for 7–8 min.; *Pisum*, 1 : 4 for 5 min.; *Pyrus* and *Betula*, 1 : 1 for 10 min.; flower-buds, 1 : 10 for 5–8 min.

Washing. Replace the loosening fluid with distilled water and preserve in a cool place for 15–30 min. (thick leaf tissues and body complexes for 60 min.).

Staining. Place four or five roots on an object glass. Cut away portions not showing divisions; suck off. For a leaf specimen, take a *small* piece from the base of a leaf on a quickly growing part of the stem. Squeeze flower-buds into pieces so that large portions of the bracts are picked off with a pincette. One drop of staining solution is added. With an ordinary piece of stiff eraser rubber (*a*) tap gently on the cover glass, (*b*) press fairly gently over the whole cover glass, (*c*) press hard with short vibratory movements, (*d*) lift the cover glass until the staining solution flows in over the tissues. Considerably less pressure is used for leaves. Pollen mother-cells are pressed still more gently. For roots the staining time is 1–2 min. The staining fluid should be cool. Leaves of *Pisum* are stained for 30 sec., *Beta* 40 sec., those of *Pyrus* and *Betula* for 45–60 sec. For these types of tissues, 4 per cent staining fluid is used; for buds, 3 per cent solution. The pigment colours the chromosomes quite black and the plasm a faint grey.

After staining, pass a rubber roller to and fro some ten times over the cover glass, on which a filter-paper is laid.

Staining fluid. Prepare a 4 per cent solution as follows: dilute 50 c.c. of concentrated (98 per cent) acetic acid with distilled water to 100 c.c. Heat to boiling-point. Add, continuously stirring the while, 4 gm. of spirit-soluble nigrosine[1]. Boil for 3–5 min. to a weak tarry consistency. Cool and filter immediately. Keep the solution in a closed glass vessel at room temperature for about 10–14 days before use.

Two girls previously quite unacquainted with cytological and similar technique are using this method at Hilleshög. To-day their capacity is 100–120 plant-counts on root-tips per working day of seven hours. Leaf-counts can be made even more quickly than root-counts (150–200 plants per day).

GÖSTA VON ROSEN

Beet-Breeding Institute,
Swedish Sugar Company,
Hilleshög, Landskrona,
Sweden.
April 18.

[1] *Stain Tech.*, **10**, 73 (1935).

Feeding Mechanism of Water-bugs

AN account has been given by H. D. Slack of the cibarial suction pump of Corixidæ, in which a modification producing the effect of chitinous jaws was noted[1]. A full account of the head and mouth parts of *Rhamphocorixa acuminata* has been previously given by M. E. Griffith[2]. Further, H. B. Hungerford[3] has found solid food in the alimentary canal of Corixidæ, in particular, jaws of rotifers, filaments of *Oscillatoria* sp. and *Mougeotia* sp., slime diatoms, etc. In an investigation begun in 1943, I have confirmed much of this work, and, in addition, have found legs of Crustacea, *Anabæna* sp., undamaged filaments of *Spirogyra* sp., an unexploded nematocyst, pollen grains, etc. I have also made observations on the feeding of *Sigara striata*, *S. falleni*, *Corixa punctata* and *C. panzeri*, on chironomid larvæ, Mayfly nymphs and daphnids. In all cases the live food was pierced and anchored by the mouth parts, probably by the mandibular teeth described by M. E. Griffith[2]. The food thus seized was held for periods varying from five to twenty minutes, during which time some of the contents of the living animal were sucked into the corixid. On one occasion black pigment from the eye of a daphnid was observed streaming through the pharynx.

H. D. Slack suggests that the cibarial 'teeth' probably have the function of comminuting the solid food ingested, a function also attributed to the masticator described by Griffith. This may be so; but in many instances the contents of the mid-gut are found to be remarkably intact, while the finely comminuted food there is usually identical with the detritus upon which corixids frequently feed.

That there is a difference in chitinization between early instar nymphs and adults is in agreement with observations made by me on the instars of *C. panzeri*[4]. The general chitinization of the first and second instars is much less intense than in later instars and adults. An investigation of the gut contents of early instars indicates little difference in food ingested compared with that of later instars and the adult. Possibly, therefore, the heavier chitinization of the cibarial teeth in the adult is not due to a change in diet, but is part of a general increase in body chitin. An investigation of the histology of the alimentary canal and nutrition of Corixidæ was begun in 1943, and the results are shortly to be published.

MURIEL SUTTON

Department of Biology,
Chelsea Polytechnic,
Manresa Road,
London, S.W.3.
May 9.

[1] *Nature*, **130**, 605 (1947).
[2] Griffith, M. E., *Univ. Kansas. Sci. Bull.*, **30**, Part II, No. 14 (June 1945).
[3] Hungerford, H. B., *Univ. Kansas Sci. Bull.*, **11**, 1 (1933).
[4] Sutton, M. F., *Proc. Linn. Soc.*, **158**. Pt. 1, 51 (1947).

Individual Activity of Ants

FOLLOWING the publication of my note on the "Division of Labour in Ants"[1], Dr. T. Cunliffe Barnes of Philadelphia has directed my attention to his paper on "The Rhythms of Activity in Ant Colonies"[2], of which I was previously unaware.

In the course of his experiments, Dr. Barnes observed "that certain restless individuals in the group [of ants] were constantly arousing inactive individuals to activity by touching them with the antennæ". Brief details of the occurrence of this phenomenon in two experiments are given. These restless 'catalyst' ants of Dr. Barnes are the equivalent of the 'excitement centres' in my theory of the division of labour. Although Dr. Barnes did not study the behaviour of his ants in relation to the division of labour, but was only concerned with the activity or inactivity of individuals and groups, it is of considerable interest that when the ants were placed in artificial nests where they had no occupation (or queens ?) certain individual ants showed greater

physical activity than others, and were capable of stimulating the whole group of ants into similar activity. Thus even when the ants are not employed in any occupation, they may still be stimulated into undirected physical activity by individuals acting as 'excitement centres'. It would be interesting to know how far this individual liveliness is correlated with hard-workingness and laziness when ants are engaged in definite tasks (see Chen[3]) and with the ability to learn (see Schneirla[4]).

DEREK WRAGGE MORLEY

20 Robert Adam Street,
London, W.1.
April 10.

[1] Wragge Morley, D., *Nature*, **158**, 913 (1946).
[2] Cunliffe Barnes, T., *J. Gen. Psychol.*, **25**, 249 (1941).
[3] Chen, S. C., *Physiol Zool.*, **10**, 420 and 437 (1938).
[4] Schneirla, T. C., *J. Comp. Psychol.*, **15**, 243 (1933); **17**, 303 (1934); **32**, 41 (1941); **35**, 149 (1943); *J. New York Ent. Soc.*, **52**, 153 (1944), and other papers.

A New Locality for *Cyprinodon dispar* Rueppel

IN the winter of 1943–44, large shoals of *Cyprinodon dispar* Rueppel appeared in shallow water near the shore off Tel-Aviv. In the summer of 1944 they were found to be abundant in the salt pans of Athlith, south of Haifa. *Cyprinodon dispar* has not hitherto been reported from the Mediterranean Sea.

The marine specimens differ distinctly in body-shape and colour from specimens from the brackish springs in the neighbourhood of the Dead Sea. A detailed description will be published elsewhere. Specimens of both populations were kept in aquaria under like conditions and bred true to type.

H. MENDELSOHN

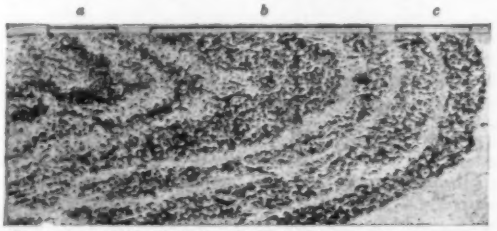
Pedagogical Institute for Biology,
Tel-Aviv.
April 21.

A Possible Central Mechanism for Colour Vision

SOME years ago, one of us submitted evidence to show that the conducting unit from the central area of the retina in man and the higher primates is a three-fibre unit[1]. It was further suggested that this anatomical fact might be related to the trichromatic theory of colour vision. Recently we have been making a detailed analysis of the main visual centre, the lateral geniculate nucleus, of the human brain, with special reference to its laminar pattern, the relative extent of the several cell layers, and their distribution over the projection areas corresponding to different parts of the retina.

In the central retinal area of the nucleus there are three cell layers related to each eye. These layers may be called *a*, *b* and *c* (the *a* layer, which is the most superficial, being composed of much fewer and larger cells). The component fibres of the three-fibre unit ending in these layers may also be called *a*, *b* and *c* fibres. It is now possible to make the following statements with reference to the human retina and geniculate nucleus. From the central area of the retina the conducting unit is a three-fibre unit consisting of *a*, *b* and *c* fibres. At the fixation point the unit consists of *b* and *c* fibres; *a* fibres are relatively very few (or may be absent altogether). From the peripheral retina there is also a functional unit of two fibres, here represented by *a* and (*b* + *c*)—that is to say, one fibre of the unit terminates in layer *a* and the other in a region of the geniculate nucleus formed by a fusion of layers *b* and *c*. If we assume (as we believe our evidence permits us to do) that there are not great variations in the fibre-cell ratio in the geniculate nucleus, we can also say that, taking the retina as a whole, the *a* fibres are much fewer than the *b* or the *c* fibres; on the other hand, the relative number of *a* fibres increases progressively towards the periphery of the retina. Lastly, from the central area of the retina, *c* fibres preponderate over *b* fibres.

We are well aware of the complexities of colour vision problems, and we ourselves do not feel competent to discuss them. Nevertheless, for the consideration of those who are better qualified in that respect, we would like to put forward the following points. If it be supposed that the *a* fibres correspond to the blue factor of trichromasy, this would explain their proportionate increase towards the periphery of the retina, which fits in with the observation that, in the distribution of colour sensitivity over the field of vision in moderate illumination, blue has the widest extent peripherally. The fact that, over the retina as a whole, the *a* fibres are much fewer than the *b* or *c* fibres corresponds with the fact that, as shown in photopic visibility curves, luminosity is least in the blue part of the spectrum and reaches its maximum in the yellow part (that is, the part representing, according to the trichromatic theory, a fusion of the red and green factors). The paucity (or possible absence) of the *a* fibres from the foveal centre accords well with the evidence that here the retina is relatively insensitive to blue. Lastly, it has been found[2] that if monkeys are kept for some weeks in light from which the blue end of the spectrum is completely excluded, the cells in the central retinal zone of cell layer *a* may undergo marked atrophic changes.



SECTION OF THE LATERAL GENICULATE BODY OF A MONKEY SHOWING SELECTIVE CELL ATROPHY IN THE CELL LAYER *a* WHICH RECEIVES CROSSED RETINAL FIBRES (THAT IS, THE FIRST LAYER ON THE LEFT IN THE PHOTOGRAPH). × 20

In the accompanying microphotograph this selective atrophy is well shown; for reasons which are not apparent, it is mainly limited to the layer which receives crossed retinal fibres only. It should be noted, also, that some degree of cell atrophy may affect the central zones of layers *b* and *c*, but this is less conspicuous than in layer *a*. If the *b* and *c* fibres are related to the red and green factors of trichromasy, then the fact that the functional conducting unit for the peripheral retina consists of *a* and (*b* + *c*) fibres explains the observation that in the field of vision the area of sensitivity for yellow extends farther than that for green or red separately; for the impulses from the receptors related to the *b* and *c* fibres would be conveyed to a common mass of geniculate cells (formed by the fusion in that area of layers *b* and *c*) and would thus not be kept segregated in the visual paths beyond the geniculate level.

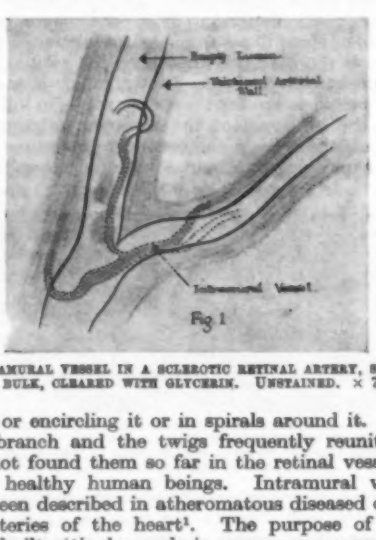
We would suggest that these correlations (together with those reported in a previous paper[1]) offer further presumptive evidence that the six-layered pattern of the geniculate nucleus (that is, two sets of three layers for the two eyes) may be related to colour vision. However, further and more detailed correlations need to be established, and much more experimental evidence is required in order to put our thesis to a crucial test.

W. E. Le Gros Clark
L. Chacko
Department of Human Anatomy,
University Museum,
Oxford.
May 27.

[1] Le Gros Clark, W. E., *J. Anat.*, **75**, 225 (1941).
[2] Le Gros Clark, W. E., *Trans. Ophth. Soc.*, **62**, 229 (1942).

Intramural Vessels in the Retina (Vasa vasorum)

Investigating ocular tissue of man and of some animals by a clearing method during the last seven years, I have found intramural vessels in retinal arteries and veins. They were discovered in bulk specimens, their existence proved later on by reconstruction of serial sections. Intramural vessels in the retina run within the wall parallel to the



Intramural vessel in a sclerotic retinal artery, seen in bulk, cleared with glycerin. Unstained. × 75

lumen or encircling it or in spirals around it. They often branch and the twigs frequently reunite. I have not found them so far in the retinal vessels of young healthy human beings. Intramural vessels have been described in atheromatous diseased coronary arteries of the heart[1]. The purpose of these newly built retinal vessels in some cases may be to bypass an obstacle in the bloodstream. In other cases with intramural vessels, however, the retinal arteries show hyaline sclerosis with preservation of the lumen. It is possible that in the latter case the intramural vessels act as vasa vasorum and improve the insufficient nourishment of the changed vessel wall. They are considered as an attempt at healing of the sclerotic process. A detailed account of these findings will be published elsewhere.

Arnold Loewenstein
Tennent Institute,
University, Glasgow.
May 12.

[1] Winternitz, Thomas, and Le Compte, "Biology of Arteriosclerosis" (Ch. C. Thomas, Springfield, Ill., 1938).

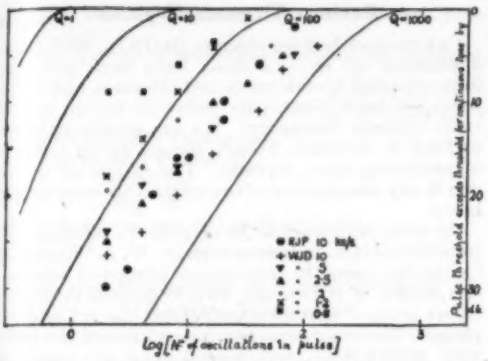
Transient Reception and the Degree of Resonance of the Human Ear

It is now more than eighty years since Helmholtz[1] gave a functional explanation of the architecture of the cochlea, and at the same time supplied a plausible physical basis for the extraordinary pitch discrimination of which the human ear is capable. Recent authorities have implicitly or explicitly rejected Helmholtz's explanation of pitch discrimination. For example, Stevens and Davis[2] say "Everything considered, then, we must conclude that the inner ear is highly damped and that this damping impairs its resolving power in the analysis of sound waves" (p. 287); and elsewhere it is implied that the damping is critical. We cannot here consider the evidence adduced by Stevens and Davis and by others in favour of high damping of the cochlea, and must limit ourselves to the blunt statement that it is inadequate. It is the purpose of this letter to put forward evidence, independent of pitch discrimination, which unequivocally supports Helmholtz's original belief.

We shall use the familiar parameter Q to describe the behaviour of resonators. For all simple resonators there is a resonant frequency, f_0, and a value of Q which is finite and positive. If such a resonator is in forced oscillation, and the frequency of the impressed force is altered from f_0 to $f_0 \pm (f_0/2Q)$, the oscillatory energy stored in the resonator is halved. Q is a measure of the selectivity of the resonator, and when Q is small the resonator is said to be heavily damped. In particular, when $Q = 0{\cdot}5$, it is said to be critically damped. For $Q > 25$ the resonator is said to be lightly damped, and when the impressed force is removed the resonator will continue to oscillate at a frequency which differs from f_0 by less than 1 per cent, and with an amplitude diminishing by $1/e$ every Q/π cycles.

Now let it be assumed that the fibres of the basilar membrane are lightly damped and independent resonant elements arranged, as Helmholtz supposed, like piano wires in ascending order of frequency from the apical to the basal end of the membrane. Further, let it be assumed that for each fibre a particular finite amplitude of oscillation is necessary to produce an audible sensation. Then, if the threshold sound intensity for a continuous pure tone is known and if a value for the Q of the fibre resonant to that tone is assumed, the threshold of audibility for a pulse consisting of any integral number of half-periods can be predicted. Conversely, if the threshold for such pulses can be measured experimentally, the Q can be determined.

We have performed this experiment for a number of frequencies between 1 and 10 kilocycles per second, and for pulse-lengths ranging from 2 oscillations to 250 oscillations. In the accompanying figure the smooth lines are calculated for a number of values of Q. The points are experimental determinations at the frequencies indicated. Considering the well-known difficulty of obtaining reproducible results from subjective auditory measurements, the scatter is small and the agreement with the predicted slope satisfactorily close. We are therefore justified in ascribing to the resonators of the cochlea a Q of about 200–350 from 2½ to 10 kilocycles, falling to about 50 at 1,000 cycles. For technical reasons we have not been able to make measurements at frequencies much below 1,000 cycles, but it is extremely likely that the Q continues to fall with frequency. If it were the same at 100 c./s. as at 10,000 c./s.,



the resonator at the lower frequency would 'ring', when the stimulus ceased, one hundred times as long as the resonator at the higher, with a consequent blurring of the appreciation of changing intensity at low frequencies. The number of discriminable intervals of pitch per octave at the lower end of the spectrum is about one twentieth of the number at the upper end[3]. Moreover, Bürck, Kotowski and Lichte[4] found that three or four oscillations are sufficient to produce a recognizable sensation of pitch at 50 c./s., whereas 250 oscillations were required at 10 kc./s. Both these facts support the belief that the Q may be 10 or less, at the extreme apical end of the cochlea.

It remains to show that the values of Q we find are adequate to explain pitch discrimination. We know already that the least perceptible increment in the intensity of a 10 kc./s. pure tone is of the order of 2 decibels, corresponding to an amplitude change of approximately 30 per cent. We assume that the resonators are equal in number to the inner row of hair cells and their resonant frequencies are distributed correspondingly to the distribution of discriminable pitch intervals; that is, there are roughly $2\frac{1}{2}$ resonators per discriminable pitch interval, and at 10 kc. a density of 470 resonators per octave. At this frequency, a frequency change of 50 c./s. can be detected. But, if the Q of the resonators is 200 and one of them responds with unit amplitude to a pure tone at its resonant frequency, the respective amplitudes of its nearest, nearest-but-one and nearest-but-two neighbours will be respectively less than unity by 25, 45 and 60 per cent, a difference more than adequate to account for the frequency discrimination actually found. A large part of the margin would, however, vanish if allowance were made for fortuitous irregularities in the series of resonators.

It is clear, therefore, that a quantitative explanation of pitch discrimination above 1,000 c./s. is possible if, and only if, our findings for the Q of the ear are of the right order. The assumption of high damping involves the complementary assumption of a far finer intensity discrimination than is either plausible or consistent with experimental data.

R. J. Pumphrey
T. Gold

Zoological Laboratory,
Cambridge.
May 6.

[1] Helmholtz, "Tonempfindung" (1862).
[2] Stevens and Davis, "Hearing" (1938); see also Gabor, *Nature*, **159**, 591 (1947).
[3] Shower and Biddulph, *J. Acous. Soc. Amer.*, **4**, 288 (1931).
[4] Bürck, Kotowski and Lichte, *Elek. Nachr. Tech.*, **12**, 355 (1935).

Crystalline Bacterial Catalase

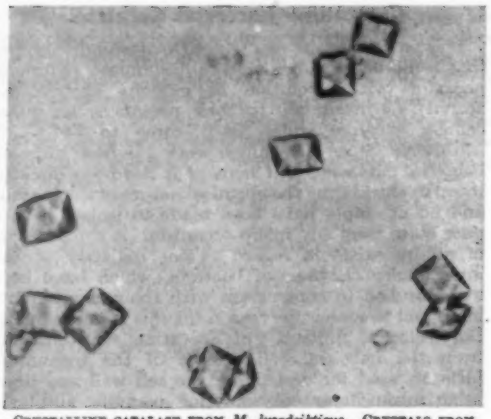
It is now fifty-four years since Gottstein[1] discovered that some bacteria are able to decompose hydrogen peroxide with evolution of gaseous oxygen, an activity he attributed to their possessing an intracellular enzyme which later came to be called 'catalase'. Since then much work has been done on bacterial catalase; but none of it has been directed towards elucidating the chemical nature of the enzyme and no attempts have been made to isolate it in a pure state from any micro-organism. A similar state of affairs exists in regard to the majority of the intracellular enzymes of bacteria, which have been little studied in comparison with their counterparts in animal tissues. One reason for this is undoubtedly the technical difficulty of liberating such enzymes from the bacterial cell. Most of the techniques hitherto used for destroying the cell wall and liberating intracellular enzymes (for example, autolysis, drying, shaking with glass beads or grinding with powdered glass, the roller-crushing mill, ultrasonic disintegration) either tend to be destructive of labile enzymes, are difficult to employ on a large scale, or require specialized apparatus.

A method having none of these disadvantages was first applied by Penrose and Quastel[2] in 1930, though it has been little used since; namely, lysis of bacteria by lysozyme[3]. This substance, which is easily prepared in crystalline form from egg-white[4], rapidly brings about smooth and complete lysis of susceptible bacteria; no specialized apparatus is required and the method can be applied on any scale.

Using this technique to liberate the enzyme, we have been able to isolate catalase from *Micrococcus lysodeikticus* in crystalline form. So far as we are aware, this is the first bacterial enzyme to have been crystallized. In outline, the technique of isolation is as follows. The bacteria are grown on C.C.Y. agar[5] in large enamelled trays, harvested, washed, suspended in 0·5 per cent sodium chloride, and lysed with crystalline lysozyme (1 mgm./gm. bacteria). The lysate is treated with 0·5 vol. alcohol at pH 5·6 in the cold, which precipitates large amounts of inert proteins and highly viscous substances formed on lysis. The supernatant liquid is shaken with 0·3 vol. chloroform which removes more inert proteins. Addition of ammonium sulphate (30 gm./100 ml.) to the supernatant liquid causes it to separate into two layers; the smaller top layer contains all the catalase. The chloroform treatment and 'layering' are now repeated, followed by dialysis to remove alcohol. The solution is now fractionated by step-wise addition of solid ammonium sulphate at pH 5·6; most of the catalase is precipitated between the limits 3·5–4 M, and is redissolved in about a tenth the original volume. It is now refractionated by careful addition of 4 M ammonium sulphate adjusted to pH 5·6. The main fraction is almost pure catalase; it is taken up in a minute amount of water and centrifuged; on standing at room temperature the enzyme crystallizes.

The crystals (see photograph) are always octahedra; no needle forms have been found. Identical crystals have been obtained by prolonged dialysis, but this is an inferior method as small amounts of protein impurity present are precipitated with the crystals.

Some bacterial enzymes (for example, lactic dehydrogenase) are known to have prosthetic groups different from their analogues in higher animals. Bacterial catalase, however, is remarkably similar to



CRYSTALLINE CATALASE FROM *M. lysodeikticus*. CRYSTALS FROM AMMONIUM SULPHATE. × *c.* 270

the crystalline catalases of horse, sheep and ox tissues.

The crystalline enzyme is an iron-porphyrin protein; its solutions have three absorption bands with centres at 6316, 5451 and 5060 A. Different preparations have contained 1·05–1·15 per cent hæmin (by direct estimation as pyridine-hæmochromogen). If the crystalline enzyme is pure, and contains four hæmin groups per molecule, the molecular weight is 226,000–248,000. Unlike animal liver catalases, all the prosthetic group is iron-protoporphyrin, and it appears to contain no verdohæmatin or similar substances producing blue pigments with acetone-hydrochloric acid. The enzyme has a greater activity than liver or blood catalase, the Kat-F.[6] being *c.* 90,000.

An interesting finding is the remarkably high concentration of catalase in *Micrococcus lysodeikticus*. From the catalase activities of the pure enzyme and the lysed bacteria, one can calculate that 100 gm. (dry weight) of this organism contain *c.* 2 gm. of catalase. Hence a single bacterial cell (dry weight taken as $2 \cdot 5 \times 10^{-12}$ gm.) contains *c.* 20,000 enzyme molecules. This amount of catalase would enable each cell to decompose about forty-seven times its own weight of hydrogen peroxide per minute (at 0° and a peroxide concentration of 0·01 *M*). Such large amounts of hydrogen peroxide could scarcely be formed as a result of cell metabolism, and it is difficult to devise any teleological explanation for this high enzyme concentration unless, as Keilin[7] has suggested, catalase has other functions besides the simple decomposition of hydrogen peroxide.

DENIS HERBERT
(Leverhulme Research Fellow)
AUDREY JANE PINSENT
(Leverhulme Research Scholar)
Medical Research Council Unit for
Bacterial Chemistry,
Lister Institute,
Chelsea Bridge Road,
London, S.W.1.
April 29.

[1] Gottstein, A., *Virchows Arch.*, **133**, 295 (1893).
[2] Penrose, M., and Quastel, J. H., *Proc. Roy. Soc.*, B, **107**, 168 (1930).
[3] Fleming, A., *Proc. Roy. Soc.*, B, **93**, 306 (1922).
[4] Alderton, G., and Fevold, H. L., *J. Biol. Chem.*, **164**, 1 (1946).
[5] Gladstone, G. P., and Fildes, P., *Brit. J. Exp. Path.*, **21**, 161 (1940).
[6] Euler, H., and Josephson, K., *Ann.*, **452**, 158 (1927); Sumner, J. B., *Adv. Enzymol.*, **1**, 166 (1941).
[7] Keilin, D., and Hartree, E. F., *Proc. Roy. Soc.*, B, **119**, 141 (1936).

Barium Titanate Crystals

CRYSTALS of barium titanate ($BaTiO_3$), with linear dimensions up to ~2 mm., have been produced from solutions in carbonates and chlorides, and (when pure) are hard, clear, pale yellow in colour, and of cubic external symmetry. We are greatly indebted to Prof. P. Scherrer, Zurich, for advice on methods of producing these crystals. The results of optical and X-ray examination of the crystals are summarized below.

At room temperature the crystals are piezo-electric (established in co-operation with Dr. W. A. Wooster, of Cambridge, using the apparatus of Giebe and Scheibe), and consist of individuals with tetragonal symmetry (space group *P4mm*), twinned about the 101 and 011 planes. The exact arrangement and size of the twins vary considerably, and depend upon the purity of the material and the stresses involved during their formation. In a simple case, the crystal consists of two sets of individuals twinned so that the tetrad axes are inclined at an angle of $90° - \gamma$, where $\gamma = 35'$ and $90° \pm \gamma$ is the angle between the diagonals of the 010 face of the tetragonal unit cell. The twin boundaries have lower birefringence and probably consist of stress-distorted, tetragonal cells which are very nearly cubic.

Above ~120° C. the crystals have cubic symmetry, *Pm3m*, and specimens can be taken through this temperature without structural breakdown; that is, the crystals maintain their rigidity and external form throughout the transition. The arrangement of the twins in the crystal below 120° C. may vary from one cycle of changes to the next, and provided no external stresses are applied, depends on the rate of cooling. Over a certain temperature-range near 120° C., both cubic and tetragonal phases co-exist in the same crystal.

The twin arrangement is sensitive to both electrical and mechanical stresses, particularly at temperatures near the transition (~120° C.), and also near 0° C. where the axial ratio *c*/*a* has a maximum value[1]. This accounts qualitatively for the maxima of incremental permittivity observed at these temperatures. On the application of such stresses the twins re-orient themselves so as to reduce the resultant internal stresses, and this is achieved by an increase in the proportion of the crystal volume occupied by those twins having the longer (polar) tetrad axis perpendicular to the applied mechanical stress (assumed compressive) or parallel to the applied electric stress. The increase in volume of any component is effected by a displacement of the twin boundary in a direction perpendicular to the plane of the boundary.

The ferro-electric characteristics of barium titanate have already been established by Hulm and others (see following communication), and our optical and X-ray diffraction studies enable us to associate the individual single-crystal components with ferro-electric domains; in some cases truly single crystals, assumed to consist of a single domain, have been observed at room temperature, but they tend to be unstable, especially just below 120° C.

Work is now in progress from which we hope to establish the exact atomic parameters in the unit cell of this and some allied materials, so providing the experimental basis for the theoretical discussion of the spontaneous electric polarization observed. We also propose to investigate in detail the behaviour of these materials at temperatures below room tem-

perature, where other crystallographic changes have been noted.

A full account of these researches will be published later.

H. F. KAY
R. G. RHODES

Crystallographic Laboratory,
Cavendish Laboratory,
Cambridge.
May 28.

[1] Megaw, H. D., *Proc. Roy. Soc.*, A, **189**, 261 (1947).

Dielectric Properties of Single Crystals of Barium Titanate

THE dielectric properties of some of the single crystals of barium titanate prepared by H. F. Kay and R. G. Rhodes (see preceding communication) have been measured at various field strengths and temperatures. The average linear dimension of the crystals available was 0·4 mm., and it was found convenient to mount them in thin disks of a phenol-formaldehyde resin. Silver electrodes were vaporized on to the two exposed faces, and the electrical contacts were pressed against the silver on the resin, so as not to stress the crystal. The electric field was applied along a direction which was a cubic axis above the Curie point, and contained a mixture of the three tetragonal axes, in various domains, at room temperature. A circuit essentially similar to that of Sawyer and Tower[1] was used to display the polarization-electric field curve at 50 cycles per second on a cathode ray tube.

Typical hysteresis loops obtained at various temperatures are shown in Fig. 1. Such loops were photographed for a series of maximum field strengths at each temperature, and the curve of maximum polarization against maximum field strength shown in Fig. 1 was derived. At 18° C. the curve rises steeply with increasing field and then gradually flattens. The region *AB* presumably corresponds to complete orientation of the ferro-electric domains in the field direction; its small gradient is of the same order as

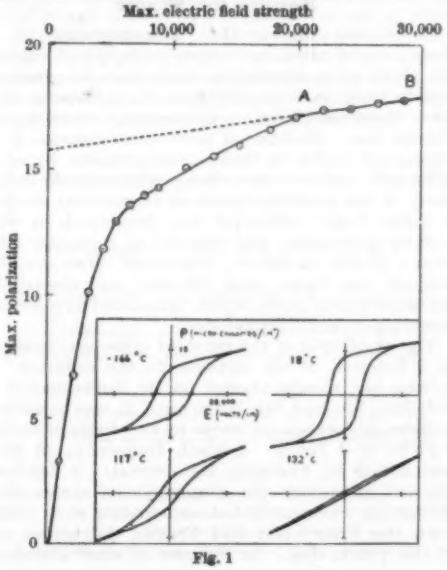


Fig. 1

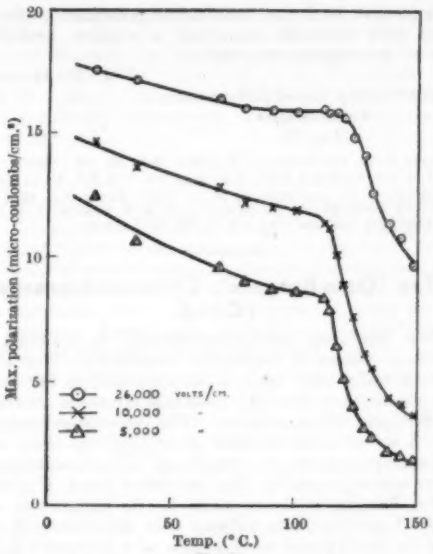


Fig. 2

the weak field susceptibility found with a Schering bridge, and is perhaps due to ionic distortion. By extrapolating *AB* back to the polarization axis, the permanent polarization characteristic of a single domain in zero field may be estimated as about 16 micro-coulombs per sq. cm., which is much greater than that of the other known ferro-electrics. The permanent polarization values for other crystals examined agreed within about 10 per cent, which is the order of uncertainty in measuring the effective area used; the coercive field, however, varied widely between crystals, from about 5,000 to 20,000 volts per cm.

Measurements on polycrystalline specimens by the same method show a maximum polarization of about 5·3 micro-coulombs per sq. cm. at 20,000 volts per cm., and similar results have been obtained by Wul and Goldman[2]. It is probable, however, that saturation for a polycrystalline aggregate is far from complete at this field strength, perhaps due to large internal strains which prevent complete alignment of domain directions in the fields available.

The behaviour of a single crystal at high temperatures is shown in Fig. 2, where maximum polarization is plotted against temperature for various field strengths. The polarization is fairly constant up to about 110° C., and then drops at a temperature slightly dependent on the field strength. Above about 130° C. the polarization – field relation becomes almost linear, though still corresponding to a very high dielectric constant which falls off according to a Curie–Weiss law. Estimation of the Curie temperature, at which hysteresis should disappear, is made difficult by an appreciable non-linear conduction above 100° C., which cannot be completely compensated and causes a slight apparent hysteresis. Detailed examination of the results suggests a Curie temperature of about 124° C., in good agreement with previous determinations on polycrystalline specimens[3].

Preliminary measurements down to 20° K. show that permanent polarization effects still exist at low temperatures; the coercive field is larger than at room

temperature and the maximum polarization for a given field strength amplitude is smaller, probably due to incomplete saturation.

J. K. HULM

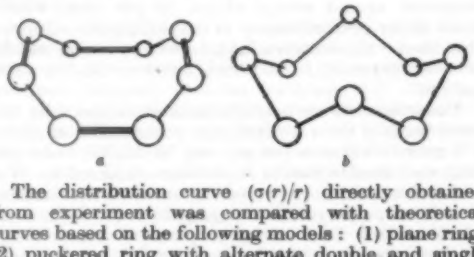
Royal Society Mond Laboratory,
Cambridge.
May 23.

[1] Sawyer, C. B., and Tower, C. H., *Phys. Rev.*, **35**, 269 (1930).
[2] Wul, B., and Goldman, I. M., *C.R. Acad. Sci. U.R.S.S.*, **5**, 21 (1946).
[3] Rushman, D. F., and Strivens, M. A., *Trans. Farad. Soc.*, **42** A, 231 (1946). Von Hippel, A., Breckenridge, R. G., Chesley, F. G., and Tisza, L., *Ind. and Eng. Chem.*, **38**, 1097 (1946).

The 'Octa-Benzene', Cyclo-octatetraene (C_8H_8)

THE fact that cyclo-octatetraene—in contrast to benzene—shows a markedly unsaturated character has generally been used as an argument in favour of the assumption that the molecule contains alternate double and single bonds. The resonance energy, which is not much smaller per CH-group than that of benzene, makes the correctness of this assumption seem rather doubtful. On the other hand, a preliminary Raman analysis leads E. R. Lippincott and R. C. Lord, jun.[1], to believe that the spectrum can best be interpreted on the basis of a puckered eight-membered ring with alternate single and double bonds.

An electron diffraction analysis of the vapour carried out recently, using the sector method, leads to a different conclusion. This analysis indicates that all the C—C bonds are equivalent, and that the C—C—C angles are 120° just as in benzene. The C—C distance is not much greater than that of benzene (about 2 per cent).



a *b*

The distribution curve $(\sigma(r)/r)$ directly obtained from experiment was compared with theoretical curves based on the following models: (1) plane ring, (2) puckered ring with alternate double and single bonds, (3) puckered ring with equivalent bond, varying the C—H distance within a reasonable range. In case 3 only was satisfactory agreement obtained. The carbon skeleton of a model based on the assumption of alternate double and single bonds is reproduced in Fig. *a*, the carbon ring of the model resulting from the electron diffraction investigation in Fig. *b*. (It is, of course, possible that the bonds of Fig. *b* are not strictly equivalent. In this case, however, the difference between the two types of bonds is too small to be detected interferometrically.)

The 120° angle between C—C bonds indicates the presence of σ-bonds (ps^2-bonds). The additional π-bonds are based on *p*-orbitals perpendicular to the plane of the σ-bonds. The overlapping of two neighbouring *p*-orbitals is weaker than in the case of benzene because their directions are no longer parallel. It may thus be understood that the C—C distance is greater and the unsaturated character more pronounced than in the case of benzene.

We have further reinvestigated the Raman spectrum of cyclo-octatetraene. Our measurements in the frequency region below 2,000 cm.$^{-1}$ (that is, excluding the complicated region of hydrogen-stretching frequencies) are given in the accompanying table.

Frequency (cm.$^{-1}$)	Intensity	Polarization	
200 (broad)	8	*P*	
254	3	*D*	
298	3	*D*	
370	6	*D*	
659	1	*D*?	
876·8	8	*P*	
953	4	*D*	
1209	6	*D*	
1220	2	*D*?	
1442	6	*D*	
1459	0	—	1209 + 254 = 1463
1608	1	*D*?	
1639	2	*D*?	1442 + 200 = 1642
1655·5	10	*P*	
1748	0	—	2 × 876·8 = 1754

In agreement with Lippincott and Lord[1], we have found only three of the Raman lines to be polarized. We have, however, failed to observe several frequencies reported as weak lines by these authors. As seen from the table, three of the fifteen Raman lines observed by us may be explained as combination tones, leaving twelve frequencies to be interpreted as Raman active fundamentals. This is in agreement with the D_{4d} symmetry which requires three polarized and nine depolarized Raman lines in this frequency region. As a D_4 or a D_{2d} structure should give rise to five polarized and 18 resp. 17 depolarized lines, we believe that the Raman spectrum can best be interpreted on the basis of the D_{4d} model.

O. BASTIANSEN
O. HASSEL

Chemical Institute,
University, Oslo.

A. LANGSETH

University, Copenhagen.
April 25.

[1] Lippincott, E. R., and Lord, jun., R. C., *J. Amer. Chem. Soc.*, **68**, 1868 (1946).

A Pulse Method for the Measurement of Ultrasonic Absorption in Liquids: Results for Water

IT is well known that measurements of the absorption of ultrasonic waves in liquids[1-3] often do not show good agreement, and that for numerous liquids they indicate absorption coefficients many times those calculated on the assumption of a purely viscous loss. Because of these discrepancies it was considered useful to make measurements by a new technique, and one was chosen which would remove many of the possible objections to previous methods. A 'radar pulse' technique was developed, in which a short wave-train was emitted in a narrow pencil from a quartz oscillator; the sound, after travelling through the liquid, was reflected and received by the same quartz plate, which thus acted as a common 'transmit–receive' transducer.

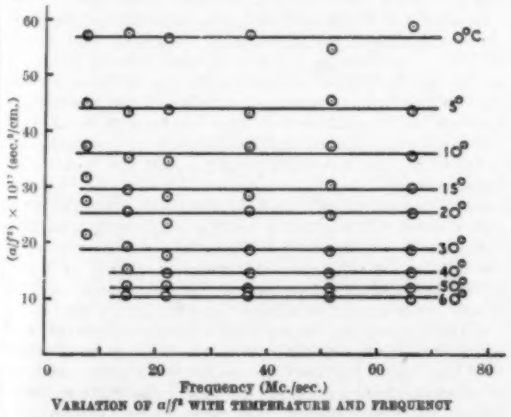
The amplitude of the received pulse was measured as a function of the distance to the reflector. By driving the quartz crystal on its fundamental and 3rd, 5th, 7th and 9th harmonics, it was possible to measure absorption of waves on five frequencies from 7·37 to 66·1 Mc./s. A sixth frequency, 15 Mc./s., was added by changing the crystal. A feature of the technique was the elimination of errors due to diffraction; concordant measurements were made in both the Fraunhofer and Fresnel diffraction zones of the quartz disk. In the case of small absorption,

that is at low frequencies, the reflector was placed in the Fraunhofer zone and the results suitably corrected[4]. It is not clear from published descriptions that due care in this connexion has always been taken in previous work.

The most important advantages of the pulse method arise from (*a*) the small mean powers which may be used, (*b*) the fact that waves which have travelled by different paths can be distinguished by the difference in their time of arrival. Many of the previous methods, especially those based on acoustic radiation pressure, require a comparatively large power, which leads to heating of the liquid, the production of cavitation, and 'streaming' of the liquid. In the pulse technique the mean power, responsible for the phenomena just described, may be kept very small; in these experiments it was about one milliwatt. Moreover, in methods employing continuous waves, it can never be entirely certain that some of the effects attributed to energy loss in the liquid (true absorption) are not due to loss of energy by scattering out of the beam. The pulse method is particularly suitable for the detection of scattered radiation, and it was easy to show that no measurable intensity of sound was scattered backwards from the liquid in front of the crystal. In addition, a direct test, using a separate receiving crystal, was made to see if any energy was scattered sideways out of the beam in water. This test showed that any loss of energy from the beam due to scattering is negligible.

The electrical method used for determining the amplitude of the received pulse permitted measurement over a much wider range than had previously been possible by other means.

The duration of the pulse was variable from 2 to 40 microsec. and the repetition frequency was 250 c./s. The received pulse was displayed after amplification on a time-base on a cathode ray tube, and an accurately adjustable set of timing marks was provided for velocity measurement if required. In order to measure the amplitude of the echo, a comparison signal was injected from a pulsed signal generator on the same frequency as the sound wave. A double-walled trough 5 ft. long contained the liquid, which was stirred vigorously; in the outer jacket, water was circulated rapidly from a thermostat. Above the trough was mounted an optical bench, fitted with a centimetre scale and sliding carriage to move the reflector. Independent fine adjustments could be made to the position of the crystal housing and reflector.



VARIATION OF α/f^2 WITH TEMPERATURE AND FREQUENCY

Measurements have now been made in water between 0° and 60° C. at 7·37, 15·0, 22·1, 36·9, 51·6 and 66·1 Mc./s. According to the theory of Stokes[5], the amplitude absorption coefficient α should be given by

$$\frac{8\pi^2\eta f^2}{3\rho v^3}.$$

If this formula holds, a plot of α/f^2 against f would be a straight line parallel to the f axis; the accompanying figure shows values of α/f^2 measured at six frequencies plotted against f for various temperatures of the water. It is seen that α/f^2 is constant within experimental error. The experimental value of α/f^2 is, however, larger than that given by the Stokes theory, as the following table shows:

Temperature	α/f^2 (sec.^{2}/cm.) mean of observed values	α/f^2 (sec.^{2}/cm.) calculated	$\frac{\alpha_{obs.}}{\alpha_{calc.}}$	Probable error (%)
0° C.	$56·9 \times 10^{-17}$	$17·09 \times 10^{-17}$	3·33	±0·6
5	44·1	13·40	3·29	±0·6
10	36·1	11·34	3·18	±0·86
15	29·6	9·59	3·09	±0·9
20	25·3	8·16	3·10	±1·35
30	19·1	6·15	3·10	±1·7
40	14·6	4·85	3·01	±0·5
50	11·99	3·98	3·01	±0·4
60	10·24	3·36	3·04	±0·8

The ratio of $\alpha_{obs.}$ to $\alpha_{calc.}$ is strikingly constant over a wide range of temperatures, although α itself changes considerably. The probable error of α/f^2, as judged from the variations about the straight lines drawn in the figure, does not exceed 1·7 per cent. It is noteworthy that the ratio $\alpha_{obs.}/\alpha_{calc.}$ shows a rise in the range 0–10° C., in which it is known that changes of structure occur in water.

(After some of the measurements had been made, a copy of the paper by Pellam and Galt[6] became available in which measurements with an essentially similar apparatus are described.)

J. M. M. PINKERTON

Cavendish Laboratory,
Cambridge.
April 24.

[1] References to earlier work can be found in Richards, W. T., *Rev. Mod. Phys.* **11**, 36 (1939).
[2] Fox, F. E., and Rock, G. D., *J. Acoust. Soc. Amer.*, **12**, 505 (1941); *Phys. Rev.*, **70**, 68 (1946).
[3] Teeter, C. E., *J. Acoust. Soc. Amer.*, **18**, 488 (1946).
[4] Born, H., *Z. Phys.*, **120**, 383 (1942–43).
[5] Stokes, G. G., *Trans. Camb. Phil. Soc.*, **8**, 287 (1845).
[6] Pellam, J. R., and Galt, J. K., *J. Chem. Phys.*, **14**, 608 (1946).

Thermionic Properties of Thoria

IT may be of interest to record our recent results on the thermionic properties of thoria coatings and of thoria in bulk. In the first experiments, a coating of thoria about 0·1 mm. thick was formed on a tantalum strip by spraying. The spraying suspension was made using an organic binder and solvent, as employed in standard techniques with barium–strontium carbonates. Direct current and pulsed emission were studied in a simple diode the anode of which could be water-cooled. The thoria surface temperature was estimated from pyrometer measurements assuming a spectral emissivity of 0·35 over the temperature range 1,800°–2,100° K.

Emission was at once available after outgassing, but rose by a factor of 3 or 4 during activation at tem-

peratures from 2,000° to 2,100° K. Richardson plots were made of the saturated emission in the steady state, applying the formula $I = AT^2 \exp(-e\varphi/kT)$. These gave a mean value for the work function of 2·5(4) eV. in the D.C. experiments, and a mean value of A of 2·5, corresponding with an emission of 2·5 amp./cm.² at 1,900° K. Higher saturated emissions were obtained under pulsed conditions, giving a work function of 2·6(2) eV. and a value of A of 7·5. Diodes were operated for 500 hours under D.C. conditions at temperatures from 1,950° to 2,050° K., taking currents of 3–7 amp./cm.². The emission fell in all cases, more rapidly at the higher temperatures, and at a rate which did not appear to depend on current density at a given temperature. In contrast with the behaviour of thoria coatings investigated by Weinreich[1], there was no rise in work function during operation, the whole of the decrease in emission corresponding with a decrease in value of A. The coatings remained white throughout, probably because the temperature was not raised above 2,200° K. A typical effect was a fall in saturated emission from 6·0 to 4·5 amp./cm.² in 500 hours at 2,000° K.

Very similar results were obtained when cathodes were prepared by sintering a layer of tungsten powder on a tantalum strip, and painting the thoria coating into the sintered layer. This procedure is of American origin, and has been described, for example, in British Patent Specification No. 568962. The activation, work function and behaviour during prolonged D.C. operation were not distinguishable from the results with the sprayed coating; the mean value of A was, however, somewhat lower. This process avoids problems of adhesion which are encountered with the sprayed coatings, probably because there is little, if any, chemical reaction between tantalum and thoria below 2,200° K., the maximum temperature so far employed in cathode processing. With both types of cathode at 2,100° K., currents have been drawn of 10 amp./cm.² under D.C. conditions and 30 amp./cm.² under pulsed conditions, with none of the breakdown effects ('sparking' or 'flashing' between anode and cathode) which are commonly encountered with barium–strontium oxide coatings.

In the second series of experiments, a thoria cathode was made in the form of a tube by extrusion and sintering. The tube, of wall thickness 0·5 mm., was heated indirectly using a central tungsten wire heater-spiral. Emission was available at once after outgassing, and activation for a short time produced a stable emission which was studied under pulsed conditions. The work function was 2·5(5) eV. and the mean value of A 3·5, corresponding with a saturated pulsed emission of 3·6 amp./cm.² at 1,900° K. The emission fell rather rapidly in the only diode so far operated over a long period, by about 40 per cent in 200 hours while drawing saturated pulsed emission at 1,930° K. In addition, a cathode of this type is sensitive to thermal shock, and cracks have developed after operation for periods varying from 20 to 250 hours.

The resistivity of the thoria as used in the tube cathodes was measured approximately, and found to be of the order of 30 ohm-cm. at 1,900° K. The resistance increased exponentially as temperature was lowered, with an activation energy of 1·1 eV. If the thoria coating had similar resistivity, in the first experiments, the resistance per cm.² of the coating would be about 0·3 ohm at 1,900° K., which is about a tenth of the resistance of barium–strontium oxide at 800° C. This may explain the greater freedom from breakdown effects. In addition, there is reason to believe there is not a significant potential barrier at the metal-semiconductor boundary, so that the voltage drop is uniform through the coating and not concentrated near the boundary as in barium–strontium oxide coatings.

The watts radiated from a thoria surface at 1,900° K. were about 40 watts/cm.², corresponding with thermal emissivity 0·5(3). From this figure the emission efficiency in milliamperes per watt can be determined.

D. A. WRIGHT

Research Laboratories of the
General Electric Co., Ltd.,
Wembley.

[1] Weinreich, *Rev. Gen. Elec.*, **54**, 243 (1945).

Use of the Cathode Ray Oscillograph for Studying the Near Infra-Red Solar Spectrum

AN apparatus has been developed in the Radiation Laboratory of the Meteorological Office at Poona for the measurement of absorption due to atmospheric water vapour in the near infra-red region of the solar spectrum by means of a cathode ray oscillograph. The working principle of this apparatus and the object for which it was developed are entirely different from those described by Daly and Sutherland and by King, Temple and Thompson[1], and it was developed independently of their work. A short paper describing it was read by me at the symposium on "Atmospheric Processes" held at the Royal Institute of Science, Bombay, under the auspices of the National Institute of Sciences of India in August 1946. This paper is at present in course of publication in a special issue of the *Transactions of the National Institute of Sciences of India*.

Work was started on this apparatus towards the end of January 1946. In the first model, which was ready by the middle of May 1946, an electrically maintained oscillating slit was used for scanning the image of the solar spectrum formed by a spectroscope. This slit was maintained in a steady state of oscillation by mounting it on a steel reed tuned to a frequency of 50 c./s., and was excited by means of an electromagnet supplied with 50 c./s. alternating current from the mains. The light passing through the slit was received by a cæsium oxide-on-silver photo-electric cell with a quartz envelope. The output of the photo-cell was amplified and applied to the vertical deflecting plates of a cathode ray tube. A 50-c./s. sinusoidal voltage obtained from the A.C. mains was fed to the horizontal plates of the cathode ray tube after passing it through a phase-shifting network. Thus the vertical displacement of the cathode ray spot was made dependent on the intensity of light passing through the slit; and the horizontal displacement was synchronized with the simple harmonic motion executed by the oscillating slit, and therefore it corresponded to the wave-length in the spectrum being scanned. Thus the cathode ray spot traced on the fluorescent screen a graph of light intensity against wave-length in the region of the spectrum being scanned by the oscillating slit.

Fig. 1 gives an idea of the performance of the apparatus in its present form, in which the oscillating slit has been replaced by a rotating disk with a number of identical slits. It shows the pattern produced on the cathode ray tube screen when the

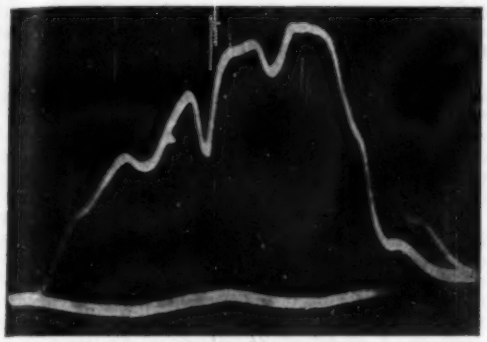


Fig. 1. Absorption bands due to water vapour and oxygen in the earth's atmosphere

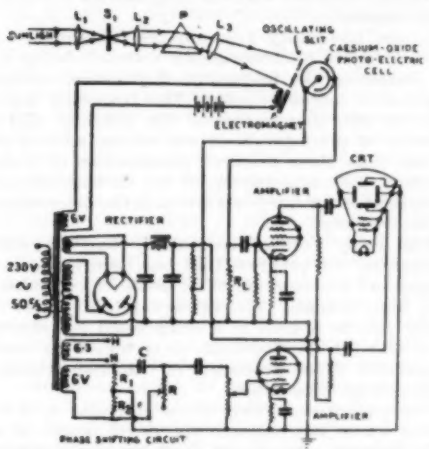


Fig. 2. Circuit diagram of cathode ray tube spectrograph

region between 0·75 μ and 1·3 μ in the near infra-red region of the solar spectrum was being scanned on a clear afternoon in January 1947. The absorption bands which can be seen in the photograph are, from left to right: oxygen band at 0·76 μ, ρ band (H_2O) at 0·93 μ and φ band (H_2O) at 1·13 μ. Fig. 2 is a schematic circuit diagram of the apparatus.

This apparatus was developed for the rapid estimation of the total precipitable water vapour in the atmosphere. Its spectral range is limited to the visible and some portions of the near ultra-violet and near infra-red regions of the solar spectrum; the limiting factors being the transmission characteristics of the spectroscope optics, which are of glass, and the sensitivity of the photo-cells, which is restricted to the region between 0·34 μ and 1·5 μ. A detailed account of the apparatus will appear elsewhere.

I wish to express my thanks to Dr. L. A. Ramdas, director of agricultural meteorology, Meteorology Department, Government of India, for guidance and for providing the necessary facilities for the work.

A. U. Momin

c/o Radiation Laboratory,
Meteorological Office,
Poona.
April 23.

[1] Daly, B. F., and Sutherland, G. B. B. M., *Nature*, **157**, 547 (1946); King, J., Temple, R. B., Thompson, H. W., *Nature*, **158**, 197 (1946). See also *Nature*, **153**, 591 (1946).

Interaction of Styrene with Magnesium Perchlorate and Other Salts

In connexion with an investigation into the mechanism of Friedel–Crafts reactions involving styrene, we required a supply of this olefin of maximum possible dryness[1]. Before proceeding to drying by evaporation in an all-glass high-vacuum apparatus of the Stock type, a preliminary treatment with magnesium perchlorate ('Anhydrone') was given. We found, however, that polymerization was induced by this drying agent: in three weeks a highly viscous polymer was obtained.

This effect can be attributed to several mechanisms. It may be due to oxygen derived from the perchlorate, to perchloric acid generated hydrolytically, or to a co-ordinating action of the magnesium atom[2]. Organic complexes of magnesium perchlorate are known, as with dioxan, while styrene forms complexes with, for example, platinum chloride[3].

To test these views in a preliminary way styrene (*a*) dried over sodium sulphate and (*b*) saturated with water, was treated with magnesium perchlorate and magnesium chloride hexahydrate. The 'dry' perchlorate system showed 13 per cent polymerization in 48 hours: the 'wet' system 6 per cent; both as judged by estimation of residual monomer using a method based on the work of Williams[4] and Mulliken and Wakeman[5].

With magnesium chloride the effect is much slower, but the 'dry' olefin is converted to a viscous polymer in two months. 'Wet' styrene is largely unaffected in the same time. This last observation may be connected with the preferential formation of phenyl ethyl chloride, much as the reduced polymerization in the 'wet' perchlorate system may be due to hydroxylation—comparable with the acetylations induced by the Bertram–Walbaum and similar reagents[6].

We have further found that anhydrous calcium sulphate, which has been recommended for drying styrene, promotes polymerization after prolonged induction periods.

The above preliminary notes do not allow us to distinguish the mechanisms of polymerization involved, which we propose to elucidate by kinetic studies using a wide range of inorganic salts. In this way we hope to obtain information about the mode of action of free radical or electrophilic catalysts, and possibly uncover new examples of the latter type.

In the meantime, we wish to indicate that it is not safe to use magnesium perchlorate for the drying of styrene, and hence probably for drying other olefins. Further, it is probably not safe to leave this olefin in contact for more or less prolonged periods with salts which can exhibit co-ordination, or which can yield strong hydrogen acids by hydrolysis.

H. S. Lilley
G. L. Foster

Department of Chemistry,
University,
Reading.
April 21.

[1] See, for example, Polanyi *et al.*, *J. Chem. Soc.*, 252 (1947).
[2] Lewis, G. N., *J. Franklin Inst.*, **226**, 293.
[3] Anderson, J. S., *J. Chem. Soc.*, 971 (1934); 1042 (1936).
[4] Williams, G., *J. Chem. Soc.*, 1046 (1938).
[5] Mulliken, S., and Wakeman, H., *Ind. Eng. Chem., Anal. Ed.*, **7**, 59.
[6] See, for example, Lennartz, *Ber.*, **76**, 831. Farmer and Pitkethly, *J. Chem. Soc.*, 11 (1938).

THE NATIONAL PHYSICAL LABORATORY

ANNUAL INSPECTION

REPRESENTATIVES of industrial organisations, university staffs and leading Government men of science were once again invited to inspect the work which is in progress during the National Physical Laboratory's 'open days', June 18–20. This second post-war exhibition followed the annual inspection by the Laboratory's General Board, of which the president of the Royal Society is chairman. Altogether, 264 exhibits were on show, illustrating the variety of work undertaken in the Laboratory's ten Divisions, and during the three days some two thousand people visited the Laboratory.

The National Physical Laboratory has grown steadily throughout its forty-six years of existence and now comprises sixteen large and a number of small buildings on a site of 60 acres. Until 1918, it was under the control of the Royal Society and, although since that date the Laboratory has been part of the then constituted Department of Scientific and Industrial Research, the Society still advises on the scientific aspects of the work.

The main aspects of the work of the Laboratory are the carrying out of research, including especially research required for the accurate determination of physical constants, the establishment and maintenance of precise standards of measurement, and the testing of instruments and materials. It also undertakes investigations of special problems on behalf of Government departments, for research associations representing various industries, and for technical institutions, industrial firms and others.

To describe any considerable number of exhibits in a short article such as this would be impossible, and mention will be made only of those items which are of outstanding general interest or which illustrate some interesting new development.

Of considerable interest to structural engineers is the research being carried out on the wind-induced oscillations of the proposed Severn suspension bridge, the centre span of which will be more than 3,000 ft. in length. The Tacoma Narrows Bridge in the United States, which collapsed in 1940 under torsional oscillation, had a centre span 2,800 ft. long. Dynamic scale models more than 80 ft. in length are being constructed for tests in a large wind tunnel specially built by the Ministry of Transport, and the structural components of these models were on view. In this tunnel, a special turntable will enable tests to be made on the model bridge at all horizontal angles of wind incidence, with wind speeds up to a maximum corresponding to 130 m.p.h. on full scale.

A more stable type of hot-wire anemometer for measuring wind speeds of less than 2 ft. per second has been recently developed at the Laboratory. In this instrument the heater wire and the thermocouple wires are carried in a twin-bore silica tube, which acts as a shield preventing deposition of extraneous matter on the wires. Considerable use has already been made of this instrument in various investigations, and it will find a ready application in such work as the ventilation of mines and buildings.

The Engineering Division had on show the results of work carried out in connexion with the adoption of a new standard thread-form by Great Britain, Canada and the United States. The major portion of this work had been completed in time for the Conference on the Unification of Engineering Standards in Ottawa in 1945, which decided upon the new form of thread to be recommended.

This Division of the Laboratory has given considerable help in the recent development of gas turbines. Work on the development of suitable bearings for use at the very high rotational speeds required, and the investigation of the fatigue and creep properties of various alloys, are of outstanding importance in this respect.

The tidal model work is now concerned with the Firth of Forth, and a model of the estuary has been constructed to a horizontal scale of 1 in 1,800. The main purpose of the investigation is the study of the deposition of silt in the approaches to Rosyth Dockyard, the dredging of which entails considerable expense. A model of the estuary of the River Wyre in Lancashire is under construction for the study of problems connected with the meanderings of the deep-water channel.

In the Electricity Division the determination of the velocity of electromagnetic waves is being made by measuring the frequency of electrical resonance of a hollow copper cylinder. This frequency depends only on the dimensions of the cylinder and the velocity of propagation of the waves, and an error of less than three hundred thousandths of a centimetre in the measurement of the dimensions allows an estimated accuracy of 9 km./s. in the determination of the velocity.

The High Voltage Laboratory had an exhibit illustrating the progress that has been made in the design and construction of an absolute voltmeter for very high voltages. This attracted-disk type of voltmeter will be housed in a compressed gas chamber, and with its development it is hoped to acquire experience of the properties of compressed gases as high-voltage dielectrics.

The quantitative study of the propagation of centimetre waves has required the development of suitable field-strength meters and standard radiators. The equipment displayed was designed for operation at wave-lengths of about 10 cm. and 3 cm., and consists essentially of antennæ of known gain (determined experimentally) relative to a half-wave-length dipole. In this sphere, a knowledge of the dielectric properties of the atmosphere and its constituents is needed for a full understanding of the propagation processes, and apparatus for the measurement of the reflexion and transmission coefficients of water at wave-lengths down to nine millimetres was also on view. The waves are reflected or transmitted through very thin plane sheets of water, and measurements on the effect of salt in solution have enabled a comparison to be made between the properties of sea- and fresh-water.

One of the interesting instruments on view was a photo-electric colorimeter employing an adjustable spectrum template. The three separate curves which measure and express the colour functions of the eye are not exactly the same for every individual, so that it has been necessary to provide an agreed set of average curves, which has been given the status of 'international standard observer'. The instrument consists of a photocell and the means to modify the response to that of the average observer. It has a wider application than the spectrophotometer, being capable of measuring not only absorption on coloured glasses or paper, but also illuminants such as discharge lamps and any colour illuminated by them. The accuracy with which the combination of photo-

cell and colour filter gives the same results as the average eye is being investigated.

During the past year an entirely new section, on control mechanisms, has been added to the Metrology Division. This group has in hand the development of an electro-mechanical differential analyser. This machine will have twenty mechanical integrators and gear systems, interconnected by electrical remote control position servo-mechanisms, which will enable it to be used either as a whole or in sections permitting the simultaneous solving of several problems. A prototype model comprising two integrators was on view. The section is also concerned with the study of the principles of automatic control, and a pilot plant has been designed and constructed for this purpose. Oil is circulated through the plant and its temperature automatically controlled by closed-cycle systems employing the proportional, the floating (or integral) or the first derivative (or rate) method of control. Alternative control methods will also be investigated.

Ternary alloys of iron, nickel and chromium form the basis of numerous commercial alloys for use at service temperatures between 500° and 800° C. It is desirable—in many cases essential—that exposure to these high temperatures should not bring about any micro-structural changes which might be accompanied by a deterioration in the mechanical properties of the alloys. One such possible change is the formation of the brittle sigma phase in alloys of certain compositions when heated within the 500°–800° C. range, and the composition and temperature ranges over which this phase is precipitated in pure iron–nickel–chromium alloys is under investigation in the Metallurgy Division. One of several interesting points shown by this work is the extreme sluggishness of the process by which the sigma phase is formed in alloys containing about 20 per cent chromium, and the effect of increasing proportions of nickel on the sluggishness of the reaction. The indications are that alloys containing about 20 per cent of chromium and not less than 25 per cent of nickel will only attain true equilibrium after many months annealing at temperatures between 550° and 650° C.

Two new induction furnaces to be added to the equipment of the Division will be used in the first place to make alloys for studying the effects of alloying elements on the properties of pure iron. One furnace, designed to melt at least 50 lb. of iron in air, has already been installed, and a second furnace designed to melt 25 lb. of iron *in vacuo* is at present under construction.

The Ship Division, working in close collaboration with the principal shipbuilders and naval architects, is rendering very useful service in solving difficulties with regard to ship-form design, and models of all classes of ships, ranging from 30,000-ton liners to 45-ton launches, are tested in one or other of the two tanks. As a result of such tests, corrections to improve performance are made in the ship and, in many cases, a final check is carried out by staff during an actual voyage. Various pieces of apparatus used in these full-scale tests at sea were on view, and hull-form tests and propulsion experiments were being carried out in the tanks.

Modern requirements as regards comfort in buildings coupled with the necessity for fuel economy have led to an intensive study of the properties of walls, roofs and floors as regards resistance to heat flow. The Physics Division of the Laboratory displayed a wide range of equipment of this nature for dealing with, say, wall-sections weighing half a ton or thin sheeting materials such as wall-boards. Work is also carried out on wall-sections of cavity construction when the external surface is subjected to a daily cycle of radiation simulating conditions in the tropics. The uniform stream of radiation is supplied by a battery of incandescent lamps run at low filament-temperature and mounted in parabolic reflectors.

Since the War, fundamental work on acoustical measurement standards has been recommenced and the section concerned has been largely re-equipped. A new development on view this year was a large acoustic duct in which plane waves of sound are generated to serve for the standardization of microphones at low frequencies and for other experiments involving low-pitched sounds.

One of the sections of the Mathematics Division, that concerned with research into new computing methods and machines, is now engaged in the development of an automatic computing engine, the ACE, and a short lecture on electronic computing machines was given twice on each afternoon during the exhibition. A correlogram calculator constructed at the Laboratory was on view. This instrument is used for calculating serial correlation coefficients direct from a continuous graphical record, and uses three pairs of wheel and disk integrators linked together by an averaging motion.

THE CHEMICAL RESEARCH LABORATORY, TEDDINGTON

REPRESENTATIVES of all elements of the chemical community and including many distinguished foreign men of science have recently visited the Chemical Research Laboratory of the Department of Scientific and Industrial Research. These 'open days' coincided with the centenary celebrations of the Chemical Society, and a large party of fellows of the Society visited the Laboratory on July 17.

The Laboratory, founded in 1925 to provide a centre for the fundamental chemical research carried out in the Department of Scientific and Industrial Research, stands in the same grounds as the National Physical Laboratory. If it has not yet achieved the wide fame of its older and larger sister, it has shown a sturdy growth during its short life and, with the ending of its war-work, is entering upon a period of vigorous activity.

Since the end of hostilities, the Laboratory has been modernized and re-equipped. A large prefabricated building has been erected during the past few months and is in full use. The new building has been named after Stephen Hales, to commemorate this great experimental scientific worker who was, for more than fifty years, vicar of Teddington. Much of the existing building has been overhauled and modified to accommodate new techniques. These include micro-analysis, high-efficiency fractional distillation, spectrography and many more. The existing facilities in such major fields as the corrosion of metals, high-pressure reactions and plastics have been improved and extended.

The buildings contain sixty-five rooms of various sizes, of which eleven are specialist laboratories and three semi-scale laboratories. The Laboratory also has a drawing office, two workshops and a glass-working room manned by skilled staff who are engaged

on the design, production and maintenance of the apparatus required in the various researches.

The programme of the Laboratory is undertaken on the advice of the Chemistry Research Board, the present chairman of which is Sir Norman Haworth. In addition to its own research programme, the Laboratory collaborates with other stations of the Department of Scientific and Industrial Research, including the National Physical Laboratory, the Fuel Research Station, the Forest Products Research Laboratory, etc., and carries out research for other Government departments. At present problems are under investigation for the Admiralty, the Ministry of Supply, the Board of Trade and the Agricultural Research Council.

The results of the Laboratory's researches are communicated to the Departments concerned, and to British chemical industry, as well as being published in the usual scientific journals. Special reports are also issued. General reviews have appeared for the period up to 1934; for 1934–37; and a review for the years 1938–46 is in the press.

The Laboratory, which is under the direction of Prof. R. P. Linstead, is organised in five main sections: corrosion of metals; inorganic; coal tar; high polymers and plastics. Provision is also made for exploratory and special work. Some past achievements of the Laboratory and a brief outline of its present work follow.

Corrosion, and particularly the rusting of iron and steel, cause losses of many millions of pounds per annum. This is not only a question of expense but also involves depletion of a natural resource which is not being renewed. It is, therefore, fitting that study of corrosion of metal and its prevention should have an important place in the programme of a laboratory established for the general benefit.

The formation of surface films by metals is a well-known phenomenon. The anodic oxidation of aluminium, discovered by this group of workers, involves a deliberate thickening of the film that forms naturally on this metal. A method of stripping films from metal, devised by Dr. U. R. Evans and improved at the Chemical Research Laboratory, has enabled the invisible films from metals such as stainless steel to be removed and analysed.

Corrosion of metals immersed in salt- or fresh-water is studied under static conditions, and when the samples are rotated at low and at high speeds. The rotor test devised at the Laboratory, although primarily designed for fundamental studies, found an immediate application on the outbreak of war in the evaluation of protective coatings for ships. Electrochemical methods now show great promise in determining the breakdown of paint films in immersed conditions. Atmospheric corrosion is especially important in relation to the present building programme, and attention is being given to the development of accelerated tests of painted surfaces. Some kinds of underground corrosion are due to the influence of bacteria. These micro-organisms are anaerobic and the damage occurs in clay or water-logged soil. The microbiological group of the Laboratory is at present concentrating on a study of these bacteria.

The experience gained in these researches on corrosion often enables the staff to assist in solving *ad hoc* problems by advice or investigation. Sometimes such work leads to useful discoveries. For example, war-work on anti-freeze materials led to the discovery of the remarkable inhibitive properties of sodium benzoate both in aqueous solution and when incorporated in wrapping materials.

Prior to the War, the Inorganic Section was investigating flue dusts and ashes as sources of semi-rare metals, but during the War special investigations were undertaken on behalf of the Ministry of Home Security. The successful outcome of one of these was the production of a fire foam agent from a cheap and indigenous source, as well as the provision of valuable fundamental information on the physical properties of foams. The possibility of making an entirely satisfactory carbon black from indigenous products was also demonstrated by this Section on a pilot-scale plant. Work on semi-rare metals has now been resumed on a broader basis. Some quantity of gallium metal and germanium halides have been prepared from indigenous material and are available for experimental work on possible useful applications.

Investigation of the composition of the tars produced by low-temperature carbonization of coal was started in 1925. The Coal Tar Section devised a scheme of separating groups of tar constituents by low-boiling solvents and dilute aqueous solutions avoiding the use of high temperatures. By this means comparative figures for tars from different sources were obtained and interesting products separated. One of these, a high-boiling tar-phenol fraction, proved very effective as a wetting agent in the mercerization of cotton, and was produced commercially as 'Shirlacrol'.

The Section is now concerned with the isolation and identification of tar constituents, using the most refined methods of separation and technique, such as high-efficiency fractionation combined with azeotropic distillation, of which a special study is being made. Allied to this is the determination of the physical and physico-chemical constants of pure coal-tar products by the most accurate methods available. Another objective is to find new uses for tar constituents or derivatives. For example, acenaphthene has been dehydrogenated to acenaphthylene, which, on polymerization or co-polymerization with styrene, yields polymers having interesting and promising characteristics.

Research on synthetic resins was one of the original topics in the programme of the Laboratory, and an outstanding contribution was the discovery of the ion-exchange resins, which has led to the establishment of a new branch of the plastics industry and to a new industrial technique. During the War, work was directed to immediate requirements, notably of the Ministry of Aircraft Production, such as the production of light-weight material using expanded resins, laminated boards and synthetic adhesives.

The High Polymer and Plastics Section is now engaged in fundamental studies of the relationship between chemical structure and the physical and physico-chemical properties of high polymers and plastics. Among the subjects under investigation are the development of improved synthetic glues and a fundamental study of ion-exchange resins with the view of producing a material of increased capacity or utility.

Pioneer work on high-pressure reactions, in the years following the founding of the Laboratory, resulted in the construction of apparatus and the discovery of catalysts by which aliphatic alcohols were formed from carbon monoxide and hydrogen, and aliphatic acids from alcohols and carbon monoxide. The high-pressure equipment then designed

and constructed has proved a useful asset in the prosecution of the Laboratory's researches, and has frequently been made use of by industrial firms and other organisations. Other subjects under investigation are the production of various useful chemicals by catalytic hydrogenation and amination. A study is also being made of the preparation and polymerization of substances containing silicon. The Organic Intermediates Section also played a useful part in the development of the new synthetic fibre 'Terylene'.

Items of biological or agricultural interest which have been investigated in recent years or are still under investigation include the discovery of one drug of outstanding properties. This substance, 2 : 7-diamino-9-phenyl-10-methyl-phenanthridinium bromide, or C.R.L.1553, has been widely used against nagana, a trypanosome disease of cattle in Africa.

In order to make further use of Colonial products, research was carried out by the Microbiological Group of the Laboratory into the production of food yeast from molasses. Yeast production up to a pilot-plant stage was successfully achieved using a special strain of yeast, and the process is now in the course of full-scale production in Jamaica.

In collaboration with stations of the Agricultural Research Council, effective sheep dips and sprays containing D.D.T. have been formulated against blowflies and sheep ticks, and special tar-acid emulsions were developed as a substitute for sulphuric acid in the destruction of potato haulm. The future policy of the Laboratory will be to extend these fruitful fields of discovery, to broaden the range of techniques available and to make the work of the Laboratory of the maximum possible value to British industry and to the chemical community as a whole.

NUTRITION IN NEWFOUNDLAND*

A STUDY of the history of Newfoundland should convince even the most hardened opponent of the need for Government planning. This island, a little larger than Ireland, a little smaller than England, has now some 320,000 inhabitants, mostly descendants of the original settlers who came from the British Isles. These settlers established themselves on the basis of one industry—cod-fishing—and sold their dry salt cod in many markets of the world. They bothered little about agriculture, and they soon depleted the stocks of game which once enriched the interior. This dependence on a single 'cash crop' meant that a bad year or a fall in the demand for their product not only spelt economic distress at the time but also resulted in a general downward trend from which the community was unable to extricate itself. In 1934 it was found necessary to suspend Dominion status.

As might be expected, this economic degradation showed in the health of the people : in a high infantile mortality-rate, in the number of still and premature births, in the incidence of tuberculosis, and in various clinical signs of malnutrition, including sporadic outbreaks of dry beriberi. In 1944 it was decided to copy the American plan of 'enriching' white flour with iron and some B-vitamins; but measures far more comprehensive than that are needed if Newfoundland's sickness is to be cured. Fortunately, there are now signs that this fact is recognized.

The nutrition workers who carried out the "Medical Survey of Nutrition in Newfoundland" in August 1944 were not content merely to report their clinical findings, but also submitted to the Commissioner for Public Health and Welfare specific recommendations for dealing with the situation, and they advised the setting up of a Council of Nutrition, "to include senior members representative of all the Departments concerned in the promotion of better nutrition of the people of the country". These recommendations were accepted by the Department of Public Health and Welfare as being "sound and essentially capable of being implemented", and a year later Dr. D. P. Cuthbertson, of the Medical Research Council, visited the island to advise on "the ways and means of approaching the programme in the field".

His report reviews the evidence compiled by the various surveys that had been made and discusses in detail the pros and cons of different methods of implementing the recommendations. The arguments range over such problems as 'enrichment' versus higher extraction rates for flour, 'uneconomic' local milk production versus imported processed milk, etc., and are therefore of interest to other territories besides Newfoundland.

From it all emerges, quite clearly, the fact that this programme for the attainment of good nutrition is going to make demands on agriculture, education, transport, industry and, not least, on the people themselves. Planning and direction are essential for, in Dr. Cuthbertson's own words, "Newfoundland . . . cannot, as at present constituted, exist as a sound economic unit capable of improving its social services so that there is freedom from want and disease".

M. W. GRANT

* Report on Nutrition in Newfoundland. By Dr. D. P. Cuthbertson. Pp. 87. (Dominions No. 4.) (London : H.M. Stationery Office, 1947.) 1s. 6d. net.

QUANTUM ELECTRODYNAMICS

THE subject of quantum electrodynamics is extremely difficult, even for the case of a single electron. The usual method of solving the corresponding wave equation leads to divergent integrals. To avoid these, Prof. P. A. M. Dirac* uses the method of redundant variables. This does not abolish the difficulty, but presents it in a new form, which may be dealt with in two ways. The first of these needs only comparatively simple mathematics and is directly connected with an elegant general scheme, but unfortunately its wave functions apply only to a hypothetical world and so its physical interpretation is indirect. The second way has the advantage of a direct physical interpretation, but the mathematics is so complicated that it has not yet been solved even for what appears to be the simplest possible case. Both methods seem worth further study, failing the discovery of a third which would combine the advantages of both.

There is another fundamental problem in quantum electrodynamics. The classical theory disagrees with experiment, in that it allows a charged particle, in the absence of an ingoing field, to build up an acceleration and to radiate energy. This difficulty can be overcome in the classical theory by imposing the extra condition that the final acceleration must be zero. In quantum electrodynamics, the first of the new methods mentioned above does not seem to need any extra condition. On the other hand, the

* "Developments in Quantum Electrodynamics", Communications of the Dublin Institute for Advanced Studies A3, 1946.

second method does need an extra condition, but it is not at all clear what form it should take.

Theoretical physics is much more complicated than it appeared earlier in this century. About thirty years ago it seemed that all physical quantities were expressible in terms of tensors. The discovery of the wave equation of the spinning electron showed that we needed also spinors. Now Prof. Dirac shows that for quantum electrodynamics we need a new kind of quantity with components which transform linearly under Lorentz transformations, which he calls an 'expansor'. It has an enumerably infinite number of components.

FORTHCOMING EVENTS

Monday, July 28—Saturday, August 2

PHYSICAL SOCIETY, COLOUR GROUP (at Cambridge).—Conference on "Colour Vision".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (temporary) IN PHILOSOPHY—The Secretary and Registrar, University College of North Wales, Bangor (August 1).

LECTURER IN APPLIED MECHANICS at the Royal Naval College, Greenwich—The Director, Education Department, Admiralty, London, S.W.1 (August 2).

SENIOR LECTURER IN ENGINEERING, and a LECTURER IN ENGINEERING OR ENGINEERING MATHEMATICS—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (August 2).

LECTURER IN ENGINEERING PHYSICS, to work in the Electrical Engineering Department of Queen Mary College and the Electro-Therapeutic Department of the London Hospital Medical College—The Registrar, Queen Mary College, Mile End Road, London, E.1 (August 2).

LECTURER IN ELECTRICAL ENGINEERING, a LECTURER IN AUTOMOBILE ENGINEERING, a LECTURER IN MECHANICAL ENGINEERING SUBJECTS, a WELDING AND SHEET METALWORK INSTRUCTOR, and a LECTURER IN BIOLOGY, at the Blackpool Technical College and School of Art—The Chief Education Officer, Education Offices, 3 Caunce Street, Blackpool (August 2).

ASSISTANT well qualified to teach MECHANICAL AND ELECTRICAL ENGINEERING SUBJECTS, at the Bolton Municipal Technical College—The Chief Education Officer, Education Offices, Nelson Square, Bolton (August 2).

LECTURER IN MECHANICAL ENGINEERING—The Director of Education, The Polytechnic, 309 Regent Street, London, W.1 (August 2).

LECTURER IN ELECTRICAL ENGINEERING, and a LECTURER IN MECHANICAL ENGINEERING—The Principal, Paisley Technical College, Paisley (August 2).

PRINCIPAL OF THE TECHNICAL COLLEGE shortly to be established in Salisbury—The Director of Education, County Hall, Trowbridge, Wilts, endorsed 'Salisbury Technical College' (August 6).

JUNIOR PHYSICIST for research in connexion with medical applications of artificial radio-elements—The Director, Radiotherapeutic Research Unit, Hammersmith Hospital, Ducane Road, London, W.12 (August 7).

LECTURER IN ELECTRICAL ENGINEERING—The Secretary, The University, Edmund Street, Birmingham 3 (August 12).

RESEARCH CHEMIST at the National Gallery, London—The Ministry of Labour and National Service, Technical and Scientific Register, Room 171, York House, Kingsway, London, W.C.2, quoting F.512.47A (August 12).

SENIOR DIETITIANS and JUNIOR DIETITIANS to the Ministry of Food—The Ministry of Labour and National Service, Technical and Scientific Register, Room 171, York House, Kingsway, London, W.C.2, quoting G.248.47A (August 14).

JUNIOR PROFESSIONAL OFFICER (woman) IN THE BRANCH OF BOTANY AND PLANT PATHOLOGY, Department of Agriculture, Southern Rhodesia—The Official Secretary, Office of the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (August 15).

REGISTRAR OF RHODES UNIVERSITY COLLEGE, Grahamstown—The Secretary, Office of the High Commissioner for the Union of South Africa, South Africa House, Trafalgar Square, London, W.C.2 (August 15).

ASSISTANT VETERINARY INVESTIGATION OFFICER—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (August 15).

ASSISTANT PHYSICIST—The Secretary, University College Hospital, Gower Street, London, W.C.1 (August 15).

LECTURER IN PHARMACOLOGY—The Dean, Guy's Hospital Medical School, London, S.E.1 (August 15).

ASSISTANT (able to undertake instruction in Mathematics) IN THE DEPARTMENT OF MECHANICAL ENGINEERING, and an ASSISTANT (able to undertake instruction in Chemistry) IN THE DEPARTMENT OF GEOLOGY—The Secretary, School of Mines, Camborne (August 23).

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF PHYSICS—The Registrar, University College, Cathays Park, Cardiff (August 23).

LECTURER (Grade IIc) IN THE DEPARTMENT OF ZOOLOGY—The Secretary, The University, Edmund Street, Birmingham 3 (August 25).

LECTURER IN MEDICINE—The Secretary, The University, Edmund Street, Birmingham 3 (August 31).

SENIOR SCIENTIFIC OFFICER in the Food Investigation organisation of the Department of Scientific and Industrial Research for work in a small laboratory at Smithfield, London, in association with the Low Temperature Research Station, Cambridge—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 1943 (September 1).

SENIOR LECTURER IN GEOLOGY at the Canterbury University College, Christchurch, New Zealand—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (September 1).

LECTURER IN GEOGRAPHY—The Secretary, Queen's University, Belfast (September 7).

CHAIR OF CIVIL ENGINEERING at the University of Cape Town—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (September 12).

PROFESSOR OF FINE ART (and Director of the Michaelis School of Fine Art); SENIOR LECTURERS IN (*a*) ZOOLOGY, (*b*) COMMERCE; LECTURERS IN (*a*) GEOGRAPHY (2), (*b*) PHYSICS, (*c*) PURE MATHEMATICS (2), (*d*) FRENCH; SUPERVISOR OF FIELD WORK (Social Science), in the University of Cape Town—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (September 15).

SENIOR RESEARCH FELLOW IN THE DEPARTMENT OF CHEMISTRY, University of Melbourne—The Secretary, Universities Bureau of the British Empire, 8 Park Street, London, W.1 (Melbourne, September 30).

SENIOR LECTURER IN MEDIÆVAL PHILOSOPHY—The Secretary of Faculties, University Registry, Oxford (October 1).

EXPERT IN TOBACCO GROWING (M.N.18166), AGRICULTURAL INSTRUCTOR IN TOBACCO GROWING (M.N.18167), for the tobacco monopoly of the Government of Iraq; TOBACCO BREEDING SPECIALIST (M.N. 18181), for the Directorate General of Agriculture, Iraq—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting appropriate Ref. No.

MECHANIC for experimental laboratory workshop in DEPARTMENT OF BIOCHEMISTRY, a TECHNICIAN IN THE DEPARTMENT OF ZOOLOGY, and a TECHNICIAN IN THE DEPARTMENT OF PHARMACOLOGY—The Establishment Officer, University College London, Gower Street, London, W.C.1.

ASSISTANT LECTURER IN GEOGRAPHY—The Secretary, Queen's University, Belfast.

HEAD OF THE PHYSICS DEPARTMENT—The Principal and Clerk to the Governing Body, Wigan and District Mining and Technical College, Wigan.

EXPERTS IN AGRONOMY (M.N.18175), PLANT PATHOLOGY (M.N. 18176), PLANT NUTRITION AND FERTILISERS (M.N.18182), COTTON BREEDING (M.N.18177), SHEEP BREEDING (M.N.18178), FORAGE CROPS (M.N.18185), BIOMETRY (M.N.18186), PLANT BREEDING (M.N.18187), AGRICULTURAL EXTENSION AND DEMONSTRATION WORK (M.N.18179), for the Directorate General of Agriculture, Iraq—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting appropriate Ref. No.

LECTURER IN CHEMICAL ENGINEERING—The Head of the Department of Chemical Engineering and Applied Physical Chemistry, Imperial College of Science and Technology, South Kensington, London, S.W.7.

UNIVERSITY ASSISTANTSHIP IN THE DEPARTMENT OF BIOCHEMISTRY—The Secretary, The University, Edinburgh.

LECTURER IN BIOLOGY—The Registrar, Municipal College, Portsmouth.

ASSISTANT ENGINEER OR TECHNICIAN FOR X-RAY DEPARTMENT, and a SENIOR ASSISTANT PHYSICIST—The Secretary, Mount Vernon Hospital and the Radium Institute, Northwood, Middx.

RESEARCH STATISTICIAN, an ASSISTANT STATISTICIAN, and a MATHEMATICAL COMPUTER—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

CHEMISTS IN THE JOINT DEPARTMENT OF CHEMISTRY, Malayan Union and Singapore—The Director of Recruitment, Colonial Service, 15 Victoria Street, London, S.W.1.

LECTURER IN ELECTRICAL ENGINEERING—The Clerk to the Governors, Heaton Technical Institute, 12 Chapel Street, Mariposl, Heanor, Nottingham.

LECTURER IN MINING at the Cannock Chase Mining College—The Director of Education (Dept. F.E.), County Education Offices, Stafford.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

British Rubber Producers' Research Association. Publication No. 72: Modern Views on the Chemistry of Vulcanization Changes, Part 1, Nature of the Reaction between Sulfur and Olefins, by E. Harold Farmer and F. W. Shipley; Part 2, Role of Hydrogen Sulfide, by Ralph F. Naylor; Part 3, Reaction of Sulfur with Squalene and with Rubber, by George F. Bloomfield. Pp. 26. Publication No. 73: A Simple Laboratory Falling-Film Molecular Still. By E. Harold Farmer and D. A. Sutton. Pp. 4. Publication No. 74: Kinetic Studies in the Chemistry of Rubber and Related Materials, 2, The Kinetics of Oxidation of Unconjugated Olefins; 3, Thermochemistry and Mechanisms of Olefin Oxidation, by J. L. Bolland and Geoffrey Gee. Pp. 18. (London: British Rubber Producers' Research Association, 1946.) [301

British Electrical and Allied Industries Research Association. Twenty-sixth Annual Report, October 1, 1945, to September 30, 1946. Pp. 148. (London: British Electrical and Allied Industries Research Association, 1947.) [32

Other Countries

Smithsonian Miscellaneous Collections. Vol. 106, No. 16: New Birds from Colombia. By Alexander Wetmore. (Publication 3862.) Pp. ii + 14. Vol. 106, No. 17: Some New Cambrian Bellerophont Gastropods. By J. Brookes Knight. (Publication 3865.) Pp. ii + 11 + 2 plates. (Washington, D.C.: Smithsonian Institution, 1946–1947.) [291

Classified List of Smithsonian Publications available for Distribution, December 1, 1946. Compiled by Helen Monroe. (Publication 3858.) Pp. iv + 53. (Washington, D.C.: Smithsonian Institution, 1946.) [291